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The Dock and Harbour Authority

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Editorial Comments

Volume 21.

The present issue marks the commencement of a new volume, the twenty-first. While the completion of another year of existence is in itself a matter for satisfaction, there is additional cause for gratification this time in that the journal has survived a year of war, and is still steadily carrying on, thanks to the loyal adherence of subscribers and the esteemed support of advertisers. We are grateful for this evidence of continued confidence, which we shall do our best to justify, in spite of the serious difficulties with which we are confronted. Our readers will, we feel sure, appreciate these difficutlies, and make sympathetic allowance if the standard of the journal should temporarily fall a little short of that under normal conditions.

The Port of The Dalles.

The Port of The Dalles in the State of Washington, U.S.A., which is the subject of a descriptive article in this month's issue, possesses a peculiar interest in that its creation is the accompaniment and, in fact, the outcome of a notable scheme of river regulation, mainly for hydro-electric power development purposes. The river in question is the Columbia River, which rises in the Rocky Mountains in Canada, and after flowing 460 miles, enters the United States territory in the North-eastern corner of the State of Washington. It crosses the state in a southerly direction to the mouth of its largest tributary, the Snake River, near Pasco, then turns westward to form the boundary between the States of Washington and Oregon, finally discharging into the Pacific Ocean about 610 miles North of San Francisco Bay and 160 miles South of the Straits of Juan de Fuca. In its course of 1,210 miles to the sea, the river drains the Western slope of the Continental Divide and the inter-mountain plateau, and cuts its way through the Cascade Mountains and the Coast Range. The total fall within the area of the United States is 1,288-ft.

For the utilisation of this potential source of hydraulic power, the improvement of the Columbia River with certain contingent works was formally authorised in U.S. Congress by the River and Harbour Act of 30th August, 1935. In addition to the provision of a dam, which is among the most notable of these structures in the United States and is required for impounding the river flow, there is also a lock bye-pass for shipping. These works are located at Bonneville at the head of tidal navigation. At a distance of some 43 miles from Bonneville, lies the new river port of The Dalles.

Further and fuller particulars of the new port and its approaches are to be found in the article on a succeeding page. It is an interesting example of a combined navigation and port development scheme with the simultaneous provision of power for industrial purposes. It is also a significant instance of the enterprising outlook of the United States Federal Authority under whose auspices and direction the development programme has been promulgated.

Port Working During Air Raids.

Considerable attention has been paid of late to the serious effect of the interruption of normal operations at ports during periods of air raid warning, in accordance with the Home Office instruction to take cover immediately the warning is sounded. A consideration of the moderate risk involved has led to a modification of this rule and work is now to be carried on until danger becomes imminent. The matter was discussed at a meeting called by the Lord Mayor of Liverpool at the Town Hall, which was attended by Sir Lionel Warner, the General Manager and Secretary of the Mersey Docks and Harbour Board, together with high military, naval and air officers. Later, Sir Lionel held a further meeting at the Dock Office in his capacity as general manager of the Board, and also as chief executive officer appointed by the Port Emergency Committee, to decide upon the best arrangements for carrying on quayside work with as little interruption as possible from enemy aerial activity during daylight hours. The meeting unanimously arrived at the conclusion, in order that the national war effort should not be impeded, that work should be continued after the first signal or " Alert " warning, until such time as bombs begin to fall in the immediate vicinity, or that danger was otherwise imminent.

The common sense of this decision is beyond question. There has, unfortunately, been much loss of valuable time in cargo handling due to warnings, which happily have not materialised. To show the absurdity of a strict adherence to the safety-first regulation, the following incident, related in a recent issue of the *Daily Mirror*, may fittingly be quoted:

" In a West of England port, a great liner lay unloading a cargo which is of vital importance to Britain. Hundreds of dockers were in her holds, on her gangways and on the quayside. The sirens went—and immediately every man stopped work. You might have expected them to rush to cover. That might have been forgiven. Instead, they spread themselves around in the sun. ' Good as a holiday for a bloke, these sirens,' said one, as he lit a forbidden pipe. The time was early afternoon. The warning was the fourth of the day—one false—and up to then 1,445 working hours had been lost to the nation, yet not a plane had been seen in the sky."

Such an incident is very regrettable, even if unique—but it is not; and it is to be hoped, in the national interest, that all employers of port labour and trade union leaders will do their best to eliminate the evil of over-caution during periods of air raid warning. In war, certain risks have to be taken, and British dock workers, we are sure, would be the last to claim special consideration for their own safety. Already, a satisfactory response has been made, and, indeed, has been simultaneously forthcoming from all sections of the community.

Timber versus Reinforced Concrete.

An article in this issue raises an interesting and important topic of a controversial character. The relative merits of timber and reinforced concrete, as structural materials for wharves and jetties, have been debated on a number of occasions, but without any very definite decision being arrived at as to the all-round superiority of either. There are, in fact, outstanding points in favour of each. It is desirable, therefore, to review the situation from time to time, in order to see whether the passing of the years has developed any fresh arguments or disclosed unsuspected weaknesses.

Timber was for a long time the sole possessor of the field. Reinforced concrete is relatively a recent invention, and though like many novelties, it was hailed with acclamation, and, indeed, forced into all sorts of uses—sensible and otherwise—there still remained many doughty champions of the older material. Among them is the contributor of the article in this issue. He discusses quite fairly the advantages and disadvantages of the materials, but concludes that the balance is decisively in favour of timber.

With this conclusion we are not inclined to disagree. Though reinforced concrete is a remarkably ingenious combination of steel and mineral, which possesses admirable qualities and has proved serviceable in the highest degree in many directions, we have always felt that there were insufficient grounds for the

Editorial Comments—continued

wholesale displacement of the older material in the construction of wharves and jetties.

Except in one case. Timber, unfortunately, is liable, to the attacks of marine organisms and despite all remedies which have been tried, and they are legion, remains very vulnerable. Natural decay, of course, occurs in tidal situations which are alternately submerged and air exposed, but this decay is nothing to the rapid deterioration which sets in when marine organisms get to work; in some cases, it is a matter of mere months before total collapse takes place. On the other hand, timbers (particularly the harder and denser varieties) which are installed in waters free from inimical marine organisms, may, and do, last for indefinite periods.

We need not pursue the matter further. Our readers will find the arguments set out very fully and capably by our contributor, and, having, as stated above, a sympathetic feeling for his judgment, we urge an attentive consideration on the part of our readers for an important problem in maritime engineering.

The Port of London Authority.

The 31st Annual Report of the Port of London Authority for the administrative year ended 31st March, 1940, extracts from which appear on another page, reflects, as might be expected, the effect of war conditions during the greater part of the period. The report itself has correspondingly suffered in that there is reticence on a number of matters of interest, to which it would be inadvisable to allude under present circumstances. There is sufficient, however, to indicate that the business of the port has been carried on as actively as has been consistent with the restrictions imposed by war-time regulations, and the partial diversion of traffic to less vulnerable centres. Figures relating to traffic, statistics of shipping using the port and the tonnages of imports and exports are not available for publication, and as these must inevitably compare unfavourably with returns under normal conditions, the consolatory reflection is that the first port of the empire managed to maintain its essential services in spite of great and almost overwhelming difficulties. A tribute is deservedly due to the members of the staff who have so bravely and capably faced the dangers and hazards of the situation.

Notwithstanding the scarcity of materials and the lack of much essential labour, the Authority has been able to carry on constructional operations in regard to certain improvement works, the nature of which cannot be disclosed, though the provision of several items of port equipment is mentioned in the report.

The state of the Authority's finances has been adversely affected and a credit balance brought forward at 31st March, 1939, has been materially reduced. To remedy this state of affairs, authorisation had to be sought from the Ministry of Transport to increase certain rates and charges, notification of which was issued in December, 1939, and March, 1940.

The term of office of the present Chairman, Vice-Chairman and other members of the Authority has been extended for one year and the next election in 1941 will be based on the register of voters made during the 12 months ended 31st October, 1939.

Port Policy of the Future.

It is inevitable that the end of the present war, when it has run its catastrophic course, will see a great many changes in the national life of Great Britain. Already there have been drastic modifications of habit and routine in the " daily round and common task " of an existence which is certainly less monotonous than hitherto, even if, perhaps, a little too exciting at times. Some of these changes will persist and become permanent. They will influence life and conduct, and may even leave a lasting impression on the national character.

Be that as it may, there is sufficient evidence to indicate transformations of a fundamental nature in commercial and shipping movements. Trade has been dislocated. It no longer circulates in the old channels and in familiar grooves. It has had to adapt itself to a different set of conditions, and new practices, which have taken root, may develop to an unexpected extent.

Before the war, there was clearly noticeable a distinct trend of industry in the direction of centralisation, both as regards location and management. Factories accumulated in certain districts and there was a marked migration of the working population, particularly from the North and Midlands of Great Britain to the South. This naturally had its effect upon the ports in these areas, at some of which the customary volume of imports and exports tended to increase, while at certain others there was a definite decline.

In this respect, the war has made a striking difference. Centralisation, whatever its merits from an administrative point of view, as a general policy is no longer desirable; indeed, it is dangerous in war-time. Industries have become scattered and segregated and the workers have naturally followed suit, not only for the purpose of securing employment, but partly under the stimulus of a desire for safety. Shipping, too, has been diverted in a number of cases from vulnerable points on the coastline to other ports where the risk of aerial attack is less acute. For the same reason it has been spread more widely.

How far these changes, intended, perhaps, merely to be temporary expedients, will assume a character of permanence and stability, is a matter for speculation. It is impossible to imagine, however, that in the coming post-war period there will be a complete, or even a general, reversion to the old order of things. There exists abundant scope for improvement in the old methods and for a broader outlook on the needs of the nation as a whole. The war has taught the port authorities of this country many things. It would be well if these lessons were taken to heart and pondered over, so that when the time comes they may result in a policy for the future which shall be sane and far-seeing.

Libyan Ports.

Certain ports on the Libyan Coast of North Africa have come into prominence recently in connection with naval and aerial military operations by the British Imperial Forces. Among these are Tobruk and Bengazi. Both are ports of modern origin or of recent development, and the following particulars, prepared from an official memorandum of the Government of Libya, published a short time ago in *World Ports*, will be of interest.

Tobruk, as lying nearest (about 60 miles) to the Western Egyptian frontier, claims first notice. The Port of Tobruk, states the memorandum, identified with the bay of the same name, which is wide and deep, is the best natural port in the whole Coast of Cyrenaica. It runs in an east-west direction and is about 2 miles long and a mile wide. The depth of water varies from 50 to 60-ft. at the entrance and diminishes gradually towards shore line. Along the western part of the north coast of the bay and to the south of the town there is stated to be a wharf, 110 yards long. It is also stated that the depth of water alongside the wharf is about 7-ft. Projecting from the wharf are two small timber piers, or jetties, one of which is 85 yards long and the other, 48 yards long. Both have a depth of water alongside of about 17-ft., the permissible draught for shipping moored at the berths being 14-ft. As the second of these piers is said to belong to the Royal Italian Navy, it is remarkable that the depth of water available should be so restricted. Obviously vessels of important calibre could not be accommodated there.

Bengazi, or Benghasi, lies further to the westward. It has been provided with a new harbour lying to the north and seaward of the old harbour. The new harbour is enclosed within two moles or breakwaters—the Main Mole and the Leeward Mole. The former, beginning at a point about 220 yards north-east of the base of the old Italia mole, extends for about 660 yards in a north-westerly direction and then proceeds in a long curve for about 220 yds. with a straight line continuation of 915 yards to the south-west, attaining a total length of just over a mile. The Leeward Mole starts near the base of the Italia Mole and runs for 605 yards in a W.N.W. direction. A third mole, the Giuliana Mole, built to protect the old harbour extends from the point of the Giuliana Peninsula in a north-westerly direction for about 1,270 yards. There is a single wharf located on the east side of the old harbour. It is 550 yards long and can accommodate ships of less than 12-ft. draught, either alongside or at anchorage. In order to reach this wharf, vessels have to navigate a channel with a depth of little more than 13-ft. There are other minor features of port accommodation including two small piers, one of wood and the other of stone, only serviceable for small craft. A small basin or " porticciuolo," is 220 yards long by 160 yards wide; the depth of water varies between 11 and 13-ft.

Unless important developments have been carried out within the past twelve months, the quayside accommodation at these Libyan ports would appear to be of a rather primitive and restricted nature.

European Inland Waterway Development.

Unlike Great Britain, Russia and Germany are two countries in which inland water transport has attained outstanding development. The cause is not far to seek. With immense tracts of fairly level land watered by long and easily navigable rivers, the inducement to extend and connect these natural waterways has resulted in the creation of a network of canals which have powerfully reinforced the transport facilities of both countries.

In recent issues we have described some of the more recent and notable installations in Germany—the Mittel-land Canal, the Dortmund-Ems Canal, the Adolf Hitler Canal, and others. In this issue, we publish a short account of a no less important undertaking now in hand by the Government of the U.S.S.R., known as the Greater Volga Scheme, whereby a twofold object will be achieved, viz., that of providing better navigation facilities over a large area of Eastern Russia, coupled with a hydro-electric power system which will serve to industrialise, and also irrigate an extensive tract of territory.

The combination of these services is becoming a common feature of modern hydraulic enterprise. Another instance is to be found in the leading article this month on the port of The Dalles, which has been evolved from the same duality of purpose. It is a practical example of the proverbial " killing two birds with one stone."

The Port of The Dalles, Oregon, U.S.A.

Creation of an Inland Port for the States of Oregon and Washington

THE PORT OF THE DALLES (not to be confused with the town of Dallas, about a hundred miles to the South-west, in the same State of Oregon), lies on the Columbia River which divides the States of Oregon and Washington, about 190 miles from its mouth. As a port it has come into existence with the construction of the great Bonneville Dam, which is the means of impounding the Columbia River above Bonneville,* about 140 miles from the sea; to which extent the river is tidal.

The Bonneville Dam, formally authorised by the United States Congress in August, 1935, principally for hydro-electric power production, embodies, in addition to the dam and power house, a ship lock and fishways. The ship lock provides the highest single lift in the world for ocean-going vessels. The lift is 72-ft. in a single stage, and the lower gates of the lock are just over 100-ft. in height.

At the rear of the dam has been formed an impounded stretch of river some 50 miles long, extending through the famous Columbia Gorge in the heart of the Cascade Mountain Range and ending about 3 miles above the city of The Dalles.

The Port Approach Channel

The projected depth of the Columbia River is 35-ft. from its mouth to the junction with the Willamette River, and 30-ft. to the City of Vancouver. From Vancouver to Bonneville the natural depths are from 7 to 50-ft. at low water and the channel is suitable for barge navigation. Above Bonneville, the depth in the impounded pool is 30-ft. or over. Provision has been made for a 27-ft. channel from Vancouver to Bonneville, so as to afford access for vessels of that draught as far as The Dalles.

The lock chamber is 500-ft. long by 76-ft. wide in the clear. The depth of water over the lower sills at low water is 24-ft. At low water the lift is 66-ft.; at normal river stage about 60-ft. and at extreme high water, 30-ft.

The lock gates are of the mitre type, made of silicon steel with horizontal girders 44-ft. long, framed with vertical and horizontal ribs, faced with plane and buckled plates. The precise height of the lower or outer gates is 102-ft., each leaf weighing 525 tons, and being provided with air chambers to reduce the working weight. The upper gates are 45-ft. high.

In anticipation of these approach works, the port has been designed in advance and constructed " in the dry " so as to be ready for shipping as soon as navigational facilities became available.

Some very interesting problems presented themselves for consideration in designing and locating this port accommodation. Not only was it necessary to locate it where an adequate depth of water would be available when the river level was raised to the impounded level, but there was also the question of ice scour, and the further question as to the effect the creation of the pool would have upon the accumulation of ice compared with ice conditions antecedently.

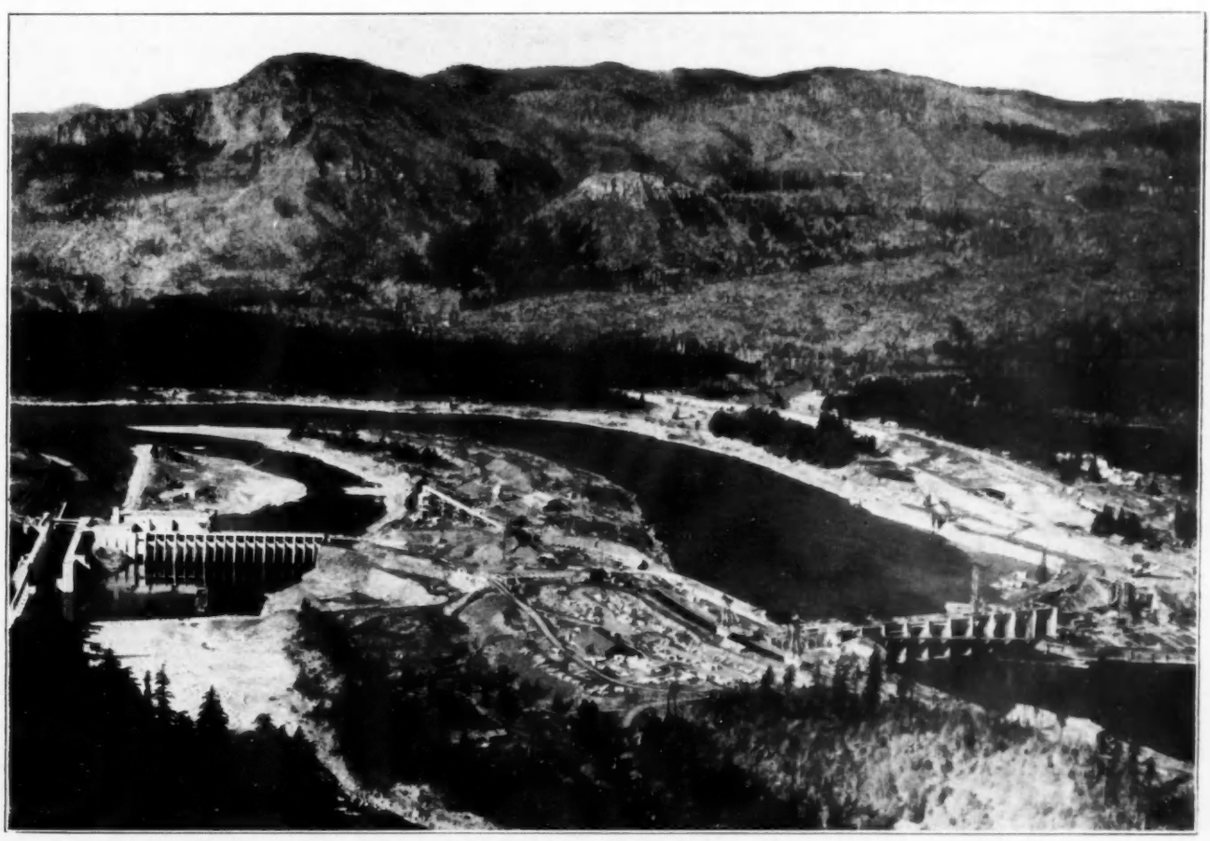
Another interesting problem was connected with the height of the wharfage. This point had to be determined from a study of flood elevations of the river over a period of many years, taking into consideration the probable effect which would be produced on the one hand by the construction of another dam—the Grand Coulee Dam—some distance upstream in the river, which would cause retardation of flood waters in their descent above the port, and on the other hand, the retardation on the downstream side due to the Bonneville Dam.

Description of the Port.

The port frontage consists of a continuous wharf, parallel with the river bank. The wharf is 1,100-ft. long and 125-ft. wide and supports two transit sheds. On both the river and rear sides of the wharf are provided 16-ft. wide aprons for runways. An approach structure 350-ft. long with a 24-ft. roadway, is located at the west end. The wharf is a timber structure supported on 3,000 untreated piles, braced transversely and longitudinally with 170 piles. All piling extends to bed rock, with an average penetration through 23-ft. of sand. The deck is of 4 by 4-in. selected fir, laid with the vertical grain up and blind-nailed. The substructure is completely fire-protected by an automatic sprinkler system and adequate fire curtains.

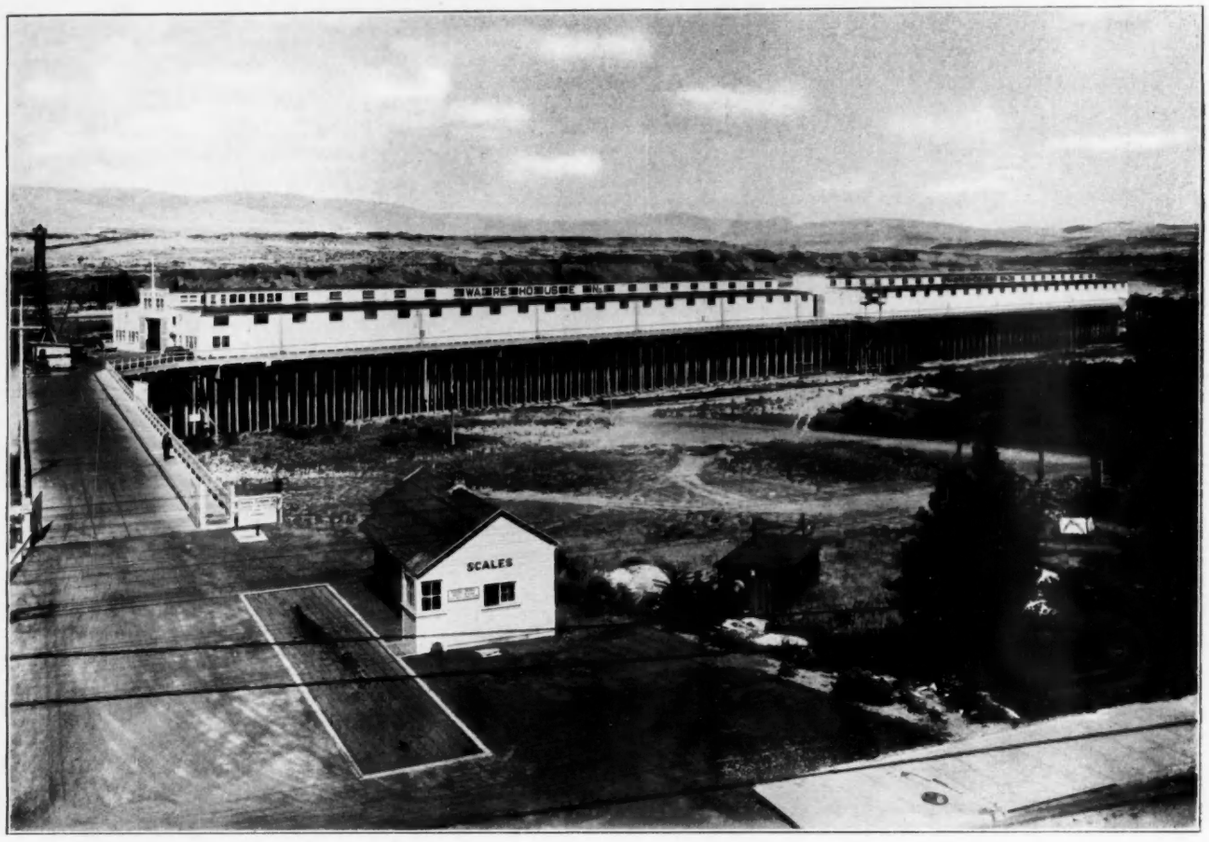
The two transit sheds are identical in size, being 460-ft. long and 93-ft. wide. Clear areas at each end and between buildings provide sufficient space for turning trucks and trailers. The buildings, of frame construction and covered with corrugated

*Bonneville is 42 miles East of Portland, Ore., which was described in an article in this Journal in October, 1937.



General View of the Bonneville Dam, on Columbia River, looking upstream showing the Ship Lock on the extreme left.

Port of The Dalles, Oregon, U.S.A.—continued



View of Quay and Sheds at The Dalles.

iron, are of the monitor type, with windows in both monitor and side walls. Each building opens on to the riverside apron by eleven 10-ft. by 12-ft. sliding doors. The total floor area of each shed is 42,780 sq. ft. and is designed for a load factor of 500 lbs. per sq. ft. Each transit shed has a normal capacity of 7,500 tons, the centre aisle being kept clear for traffic. All interior surfaces are painted with a cold-water factory white.

The columns in the sheds are spaced 20-ft. apart longitudinally. The two rows of interior columns are 32-ft. from the walls and provide a 29-ft. centre aisle. Interior posts are built up of two 6-in. by 12-in. timbers, resting directly upon the bent caps. One of the 6-in. by 12-in. posts supports the monitor beams and the other provides support for the side beams. The roof is made up of 1-in. sheathing, covered with composition roofing laid on 2-in. by 12-in. timber purlins.

General Facilities and Equipment

Office space has been provided in one warehouse by the addition of a second floor in the monitor. This office area has adequate facilities for the Port Commission, with two rest rooms and two connecting offices, which can be easily expanded. Beneath the office, on the main floor, space has been provided for the boiler room, wharfinger's office, locker room, and two offices available for lease.

The wharf is equipped with two 4-point suspension type marine elevators, located on the river side of each transit shed. Each elevator has a capacity of 7½ tons, with a platform speed of 120-ft. per min., and a maximum drift to shipside of 6-ft. The elevators are equipped with latest type safety devices, both electrical and mechanical, including a complete set of secondary load cables and limit switches. The high speed of these elevators is required for the economical handling of sacked wheat over the terminal.

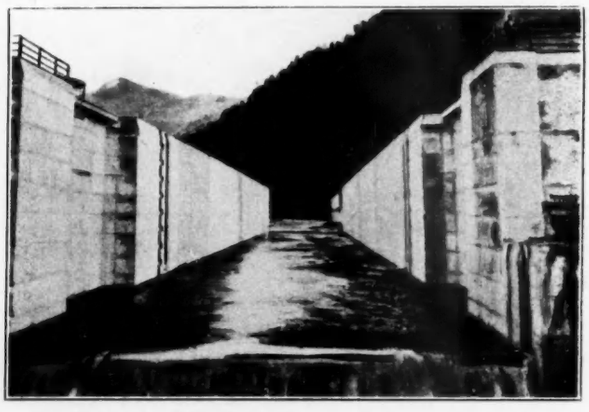
A raised truck platform has been provided on each side of the elevator in one warehouse. This platform extends 85-ft. on either side of the elevator and its 32-ft. width takes up the area from the interior posts to the side wall. The platform is 44-in. high, with a total area of 5,000 sq. ft. It is built with two "saw-tooths" one on either side of the elevator, to provide berthing space for a truck and a trailer side by side, without blocking traffic through the centre aisle. This arrangement allows lift-trucks to operate from the boats through the elevator, directly into the truck and trailers, or the reverse. The elevator will discharge over the sides to the raised deck elevation This allows the elevator to serve either the main deck level or the raised truck platform as desired. Both elevators are arranged to discharge from their sides to the river-side aprons.

A truck scale of 40-ton capacity, with a 60-ft. platform, has been installed at the shore end of the dock approach. This scale is so arranged that motor carriers may weigh entering or leaving the wharf, without jockeying into position and with a minimum of traffic interference.

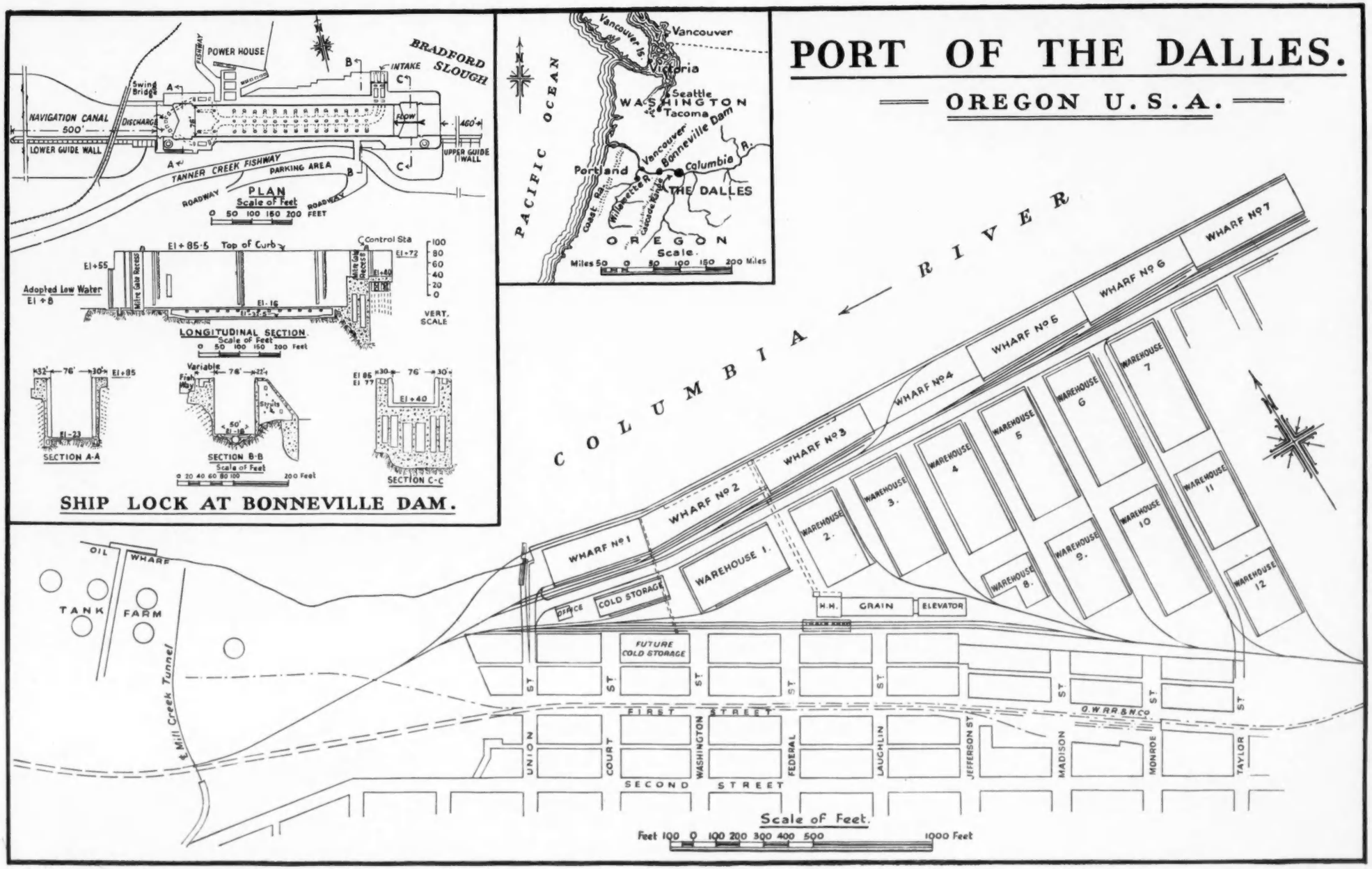
Constructional Features

Approximately 75 per cent. of the bearing piles were driven on dry land, due to the fact that the piling was driven at a water stage of El. 46.0. Following completion of the Bonneville Dam the controlled low water stage at this location is at E. 73.2. The deck level of the finished structure is at El. 97.5, which provides a free-board of 24.3-ft. at low water elevation. This is ample to provide for any extreme in flood conditions.

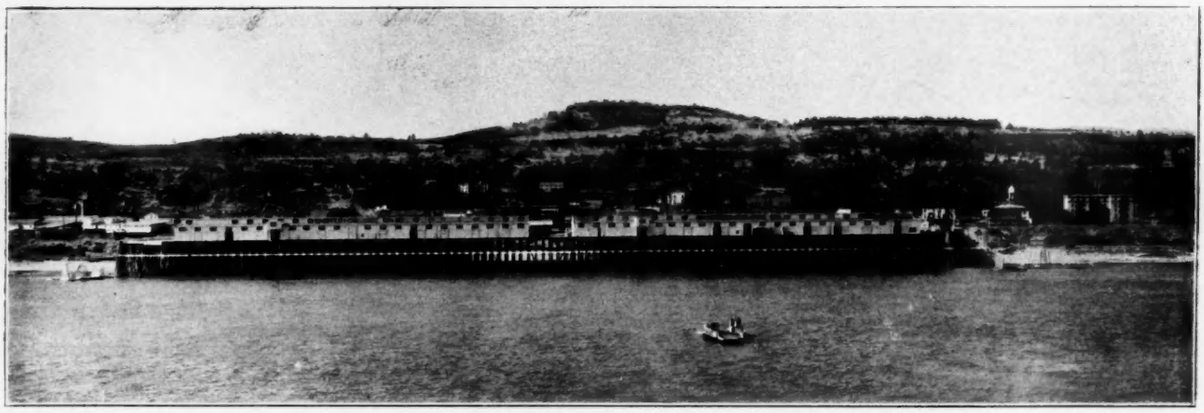
Floating leads, mounted on a dragline, were used in driving the brace and fender piling. These leads were swung upon a horizontal shaft, which was used instead of the regular top-sheave shaft of the equipment. The load line was then used to operate a 4,200 lb. drop hammer, and another line drew the leads up and under the batter piles, or tight against the fender piles. The dragline was moved along the river-side apron, setting the piles in proper driving positon, where they were lashed; the machine then backed up and drove them on the return trip. This dragline equipment, which had great flexibility and driving ability, was rigged for this work because flood conditions at



Ship Lock before installation of gates, with water flowing over the gate sill at the downstream end.


PORT OF THE DALLES.
OREGON U.S.A.
SHIP LOCK AT BONNEVILLE DAM.
POWER HOUSE
BRADFORD SLOUGH
INTAKE
NAVIGATION CANAL
DISCHARGE
LOWER GUIDE WALL
UPPER GUIDE WALL
TANNER CREEK FISHWAY
PARKING AREA
ROADWAY
PLAN
Scale of Feet
LONGITUDINAL SECTION.
Top of Curb
Control Sta
Adopted Low Water
VERT. SCALE
SECTION A-A
SECTION B-B
SECTION C-C
Vancouver
Victoria
Seattle
WASHINGTON
Tacoma
Portland
Vancouver
Bonneville Dam
Columbia R.
THE DALLES
OREGON
PACIFIC OCEAN
Scale.
COLUMBIA RIVER
WHARF No 1
WHARF No 2
WHARF No 3
WHARF No 4
WHARF No 5
WHARF No 6
WHARF No 7
WAREHOUSE 1.
WAREHOUSE 2.
WAREHOUSE 3.
WAREHOUSE 4
WAREHOUSE 5
WAREHOUSE 6
WAREHOUSE 7
WAREHOUSE 8.
WAREHOUSE 9.
WAREHOUSE 10
WAREHOUSE 11
WAREHOUSE 12
OFFICE
COLD STORAGE
H.H.
GRAIN
ELEVATOR
FUTURE COLD STORAGE
OIL WHARF
TANK FARM
Mill Creek Tunnel
FIRST STREET
SECOND STREET
O.W.R.R.&N.Co.
UNION ST
COURT ST
WASHINGTON ST
FEDERAL ST
LAUGHLIN ST
JEFFERSON ST
MADISON ST
MONROE ST
TAYLOR ST
Scale of Feet.
Feet 100 0 100 200 300 400 500 1000 Feet

Port of The Dalles, Oregon, U.S.A.—continued



View of the Port of The Dalles, looking north.

Bonneville Dam prevented the contractor from moving a floating driver from Portland at this stage of construction.

Protective Dolphin.

A protective dolphin of unusual design was driven at the upstream end of the wharf, when tests indicated that a penetration through sand to solid rock amounted to a maximum of only 15-ft. The originally designed standard 23-pile cluster lacked stability in this light penetration area. The modified design consisted of 19 piles driven in a cluster, reinforced by two legs extending toward the dock, with an internal angle of about 60 deg. Each leg has two rows of four piles battered away from the corner cluster, with one bracing pile driven between the rows and battered towards the cluster. Each leg is capped with 12-in. by 12-in. timbers, securely bolted between the tops of the piles, forming the legs and running through the centre of the cluster. The completed dolphin gives a much greater spread to the structure and provides greater stability. It is designed to furnish maximum resistance to any over-turning force, without transmitting the stress to the dock itself.

Quantities of Material Involved

The approximate quantities used in construction are:—

Untreated piles (3,000), 180,000 lin. ft.
Lumber, 2,000 m. ft. bm.
Corrugated sheet metal, 50,000 sq. ft.
Composition roofing, 70,000 sq. ft.

Labour Statistics

Wages paid, $60,000
Men employed, 152.
Number 8-hour days, 12,000
Local labour employed, 40%

Personnel

The Personnel of The Dalles Port Commission includes: W. R. Bailey, President; C. L. Nellor, Port Manager; Col. B. C. Allin, of the Port of Stockton, Calif., Consulting Engineer*; Mark R. Colby, Associate Engineer; and Charles Hageman, Resident Engineer in charge of construction. The Public Works Administration Staff includes: C. C. Hockley, Oregon State PWA Director; R. H. Corey, State Engineer-Inspector; John J. O'Farrell and H. D. Newell, Resident Engineer-Inspectors.

The entire project was carried through by Parker-Schram, Contractors, of Portland, Ore., under the direction of Superintendent Frank Watt. Mr. Ed. Yager was the contractor's office engineer and manager. Constructional operations were began in December, 1935, and were completed the following year. The cost was about $260,000.

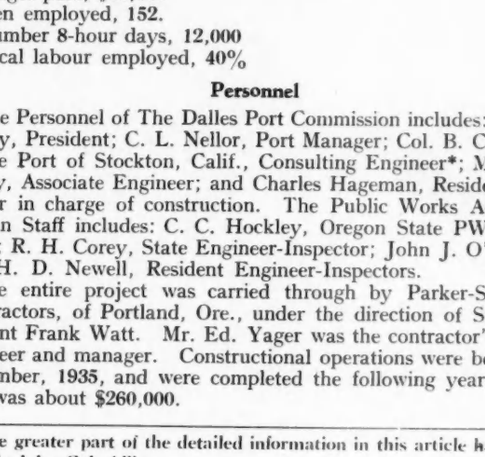
*The greater part of the detailed information in this article has been furnished by Col. Allin.

Notable Port Personalities

IV.—The Rt. Hon. Lord Ritchie of Dundee, D.L.

The Rt. Hon. Lord Ritchie of Dundee, D.L., Chairman of the Port of London Authority and Chairman of the London Port Emergency Committee, was born on November 18th, 1866, and is the only surviving son of the late Rt. Hon. C. J. Ritchie, Chancellor of the Exchequer in Mr. Balfour's administration, who was created a Baron in 1905. Lord Ritchie was educated at Westminster School and Trinity College, Oxford, and graduated in Arts in 1888. For many years he was a partner in the firm of Wm. Ritchie and Son, jute spinners and manufacturers and East India merchants, of London and Dundee, and his association with this branch of commerce is still maintained by reason of his chairmanship of the Santa Gertrudis Jute Mills Co., Ltd. He was a member of the Joint Committee of both Houses of Parliament which considered the Port of London Bill in 1908, and was appointed a Member of the Port of London Authority from its inception as a representative of the Corporation of the City of London. He was Chairman of the Law and Parliamentary Committee (1909-1913) and Chairman of the Finance Committee (1914-1919). He was Vice-Chairman of the Authority from 1913 until March, 1925, when, following the resignation of Viscount Devonport, he was elected to the chairmanship, since which time he has devoted all his energies to forwarding various schemes for the improvement and development of the Port of London.

Lord Ritchie was Mayor of Winchelsea in 1924. He is deeply interested in philanthropic work and is President of the Poplar Hospital for Accidents (the "Dockers'" Hospital). He is one of H.M. Lieutenants for the City of London and is a Director of the Ionian Bank, Limited, and of the New Zealand Loan and Mercantile Agency, Limited, and a member of the governing body of Westminster School.



The Rt. Hon. LORD RITCHIE OF DUNDEE, D.L.

Lord Ritchie has interested himself in all the leisure-time sport and social activities of the staff of the P.L.A., and has been a regular exhibitor of water colours at the annual Staff Arts and Crafts Exhibition.

Relative Values of Reinforced Concrete and Timber in Jetty and Wharf Construction

CONTRIBUTED.

Use of Reinforced Concrete in Maritime Works.

FOR many years past, development in the use of reinforced concrete for structures on land in lieu of brickwork, timber and steel has assumed dimensions of gradually increasing importance. In many cases, such as ordinary buildings, grain and coal silos, road bridges and similar structures, the results have been eminently satisfactory as regards suitability for the purpose, economy in construction and maintenance costs, as well as in increased security against the risks and losses due to fire. It is, however, only during the last 30 years or so that attention has been directed to any great extent to the desirability of replacing the more or less standardised methods of construction in quay and dock work by the use of reinforced concrete in its various forms. This marked relative discrepancy is, no doubt, in part due to the severer conditions to which the material is subjected in sea water.

One of the main arguments put forward for the adoption of reinforced concrete in sea works is the fact that in the infested waters of many ports and harbours the ravages of the teredo and other marine organisms on timber structures assume such alarming proportions that their upkeep and replacement is a costly and difficult business. Owing to the depredations of these borers, the useful life of timber at many ports where the water is saline and pure, does not reach much more than 10 to 15 years, except where the harder and more expensive varieties of timber, such as Greenheart, are employed.

This being the case, it is evident that the substitution of such a material as reinforced concrete, under the conditions referred to, would present many advantages.

In the first place, reinforced concrete can be utilised profitably in any structural method in which timber is commonly used, and in addition can be adapted in a way unsuitable for timber, viz., as a substitute for masonry and concrete in " gravity " walls.

Moreover, reinforced concrete is fireproof, and although this superiority over timber does not confer such great advantages in sea work as it does on land, the timber in the former case being surrounded with water and practically always in a state of saturation and consequently of little flammability—in fact, the destruction of a timber quay by fire is uncommon—yet in the case of quays and wharves used for the discharge of petrol, oils, etc., or when inflammable materials are present in large quantities in the vicinity, it is an obvious advantage to have the structure and its foundations of as fireproof a character as possible.

Superior Merits of Timber

Having stated these two advantages, it may be observed that in every other respect timber has an undoubted superiority. Before entering into details of the evidence supporting this contention, it is necessary to point out that in those particular cases referred to, where the life of timber is so short as to make any possible alternative economically imperative, the complete immunity of reinforced concrete from the attacks of the teredo, limnoria and similar sea organisms, notwithstanding its liability to deterioration in other directions under these conditions, presents advantages of such paramount importance as to override any possible disqualification.

But in ports where the waters are not sufficiently saline, or where they are diluted with fresh water loaded with the detritus from mills and factories, or where a faulty sewage system allows of their being fouled with nitrogenous matter, in short, at any harbour where the conditions are such that the teredo, limnoria and their kindred find living hard and the conditions for propagation unfavourable, there would appear to be no doubt that on all counts except that of fire resistance, timber is the more suitable material for use in the construction of wharves, jetties, etc.

It is difficult to enumerate these cases, but undoubtedly there are harbours in existence where the life of timber in sea work is of such a duration that it is impossible to put a limiting figure on it; and, in this connection, it may be stated that if timber in sea water is known at any particular port to be in existence after 100 years without any very definite signs of deterioration, it can for all practical purposes be considered as imperishable, and certainly as permanent as most other materials.

In such a case, as already pointed out, it is superior to, and has very definite advantages over, reinforced concrete, the reasons being as follow:—

In the first place, and by no means the least important, experience has shown that shipowners prefer mooring their vessels against timber rather than against concrete or masonry, and this is especially so in the case of ship builders when requiring accommodation for the fitting-out of the largest type of Atlantic liners, representing such a huge sum of money that the ratio of value of ship to quay might be anything from 30 or 40 to 1, and their preference is easily accounted for. Being human, they prefer, in the case of collisions between their vessel and the quay or jetty, an event not always avoidable owing to the fact that such a vessel is of an enormous size, and, on the particular occasion referred to, generally of light draught—that any damage done should be done to other people's property rather than to their own; and this, no doubt, would be the case in an encounter between a steel ship and a timber quay. It would have the additional advantage, outside the question of property, that any such damage could be repaired without unnecessary delay, whereas a collision between a vessel and a concrete wharf, or stone quay, might result in such damage to the vessel as would necessitate its docking for repair, with the corresponding delay and demurrage, which, in the case of a large and valuable ship, costing perhaps some millions of money, might easily be a matter of considerable amount. In addition, the timber structure, being more flexible, would " give " with any impact, thus reducing the likelihood of a permanent damage. In the case of a reinforced concrete structure, it is possible and indeed probable, that both vessel and wharf would suffer. The repair of the latter would be a relatively serious affair, owing to the necessity of allowing the new concrete time to mature, during which it would not be permissible to subject it to any stress, with the result that the portion under repair would be out of commission. In the case of timber, however, as a rule the repair is a simple matter and can be carried out without seriously interfering with the use of the wharf by the vessel.

Greater Strength of Timber

In the second place, and this is all important, a Timber Quay is much stronger than a Reinforced Concrete Quay. When the word " stronger " is used, a definite relation is intended, viz., stronger as a quay; and of course it is understood that, in making a comparison of this sort, like being compared with like, that is to say, a 12-in. by 12-in. timber pile is being compared with a 12-in. by 12-in. reinforced concrete pile, 6-in. timber decking with 6-in. concrete decking, etc., there being the same number and spacing of piles, bracings, etc.

As the question of the number, section and spacing of piles, is decided for other reasons than that of the vertical load they have to carry, it will be found that, unless in very exceptional cases, the strength of the pile as a column is no criterion of the strength of the quay.

For instance, to give an example of what is referred to, in the case of a certain reinforced concrete jetty—length 540-ft. and breadth 50-ft.—the total number of piles was 180, the section of the main piles being 16-in. by 16-in. and the front ones 18-in. by 18-in. Assuming a load of 6 cwt. per sq. ft. on the jetty, this would represent an average load of 45 tons on each pile, and as the safe load on a 16-in. by 16-in. reinforced concrete pile as ordinarily designed, and with certain reasonable assumptions, is between 80 and 90 tons, and on an 18-in. by 18-in., is 100 to 110 tons, there is obviously a large surplus of strength; and this is emphasised by the fact that the safe load is based on the presumption that the whole available area supported by the piles is loaded to the maximum at one and the same time—a phenomenon that is rarely, if ever, experienced in practice.

Consequently, as already stated, the conclusion is arrived at that in ordinary practice—and this will apply both as regards design in timber and in reinforced concrete—the question of the strength of the piles to carry the vertical load is not the controlling factor, and in point of fact the number of piles provided for other reasons will be found more than ample for any vertical load likely to be put on them.

The main question, then, in designing a piled and framed structure to be used as a jetty or wharf, is its capacity to stand the stresses due to the impact of a vessel coming alongside, as well as the ordinary stresses encountered by the fact of a vessel being moored to it. Both of these will generally be found in ultimate analysis to be simply a question of the force of wind and the area exposed to it, and this will apply whether the vessel is being

Relative Values of Reinforced Concrete and Timber—continued

driven on to the jetty or held to it by the pull or mooring pawls.

If it be assumed that the erection consists of a single row of piles without bracing of any sort, and, further, that this row is limited to a single pile, the problem is reduced to its simplest elements. In this case, the single pile is obviously a cantilever fixed at some more or less indeterminate point between the level of the ground and the point of the pile, the load being carried by the pile at some point between high and low water, determined partly by the vessel and partly by the system of fendering adopted. When the remaining piles and bracing, etc., are added, the main conditions are in no way altered so far as the nature and application of the stress in the pile under consideration is concerned. It still remains a cantilever, the only change effected by the addition of other piles being that it is relieved of a portion of its load, which is transferred in some cases partly to strut piles and partly, by means of the bracing timbers, to the remaining piles which also become cantilevers.

Consequently, a comparison of the relative strengths of timber and reinforced concrete, as far as piles are concerned in jetties or wharves, is simply a comparison of their strengths as cantilevers or beams. If this is admitted it will be found that it is here that timber (say pitch pine or Douglas fir) presents decisive advantages over reinforced concrete. If a 12-in. by 12-in. pitch pine pile, 40-ft. long, is compared with a reinforced concrete pile of the same size and of a common type (say with four 1-in. diameter bars), the ratio of the safe working load of the former to that of the latter is approximately as $2\frac{1}{2}$ to 1, the factor of safety in timber being taken as 10; whilst if ultimate strengths are compared, it is found that pitch pine is approximately 6 or 7 times stronger than reinforced concrete.

This amazing difference in ultimate strength is very little recognised, as the arguments are generally based on safe loads so far as relative values are concerned, but this figure is worth examination.

Influence of the " Factor of Safety "

The nominal figure for the factor of safety in ordinary reinforced concrete is, for steel, 2 (the yield point of the material being assumed to be the ultimate strength in this case) and for concrete, 4, but in practice, owing to the combination of these two materials and partly to a certain " no man's land " between the yield point and the ultimate strength of the steel, the actual figure developed, based on these figures, amounts to as much as $3\frac{1}{2}$; that is to say, it has been found in practice in many cases that the pile will carry before collapse $3\frac{1}{2}$ times the safe load for which the work was designed. The smallness of the factor of safety in this case is justified by the uniformity achieved and the control maintained in the manufacture of the materials, and this is especially so as regards the steel.

In the case of timber, however, the figure of 10, which is recommended by most of the authorities and is commonly adopted as a factor of safety, is unduly high. This figure has been arrived at on account of the want of uniformity of the material, or perhaps, owing to its being a vegetable growth and not manufactured by man, the want of knowledge as to whether there is uniformity or not (it has sometimes been called a " factor of ignorance "), but, in any case, this relatively high figure is based on the theory that in any particular stick, notwithstanding the usual careful examination, there may be hidden defects of serious moment which must be covered, as it were, by insurance in the form of a high factor. But this factor of 10 should only have reference to the case where the load is applied to one particular piece of timber. In the case of a jetty, or wharf, where there are hundreds of piles braced together to form a whole, it is obviously an excess of caution to assume that each single pile has a serious hidden defect; and as no single pile should have to support a load unaided, it is therefore claimed that in this case the factor of safety of 10 referred to would be unduly conservative, the suitable figure being 4 or 5, or, indeed, the same as in the case of reinforced concrete, viz., $3\frac{1}{2}$. Assuming the last figure, timber would be at least four times stronger than reinforced concrete, based on safe loads, and this would apply not alone to the piles as cantilevers, but also to the joists and decking or any members acting as beams.

From this it would appear that the practice of placing reinforced concrete piles at a distance of 12 to 15-ft. apart longitudinally—a common practice—as against timber piles at 6 or 7-ft. apart, is entirely unjustified, as it is not in reality a relative saving, but merely a reduction in the relative strength of the structure; and this is further emphasised if the vessel (as is sometimes the custom) is moored some distance off the quay by means of pontoons or floating fenders, in which case the total stress transmitted by the vessel is distributed over very few piles when they are placed 15-ft. apart.

Greater Economy of Timber Jetties

When it is considered that a jetty in timber, such as pitch pine or Douglas fir, can be built for less than one-half the cost of a similar structure in reinforced concrete as ordinarily designed, it will readily be seen what a huge economy can be effected by the use of timber, if the comparison were made on the basis of their relative ultimate strengths as hereinbefore set out.

The relative costs of 12-in. piles ready for driving, of reasonable length (say 40-ft.) were, pre-war, in round figures,* assuming:

Round larch as 1; Oregon pine as 3 (creosoted); pitch pine as 4 (creosoted); Greenheart as 6; and reinforced concrete as 6; so that an Oregon pine (Douglas fir) pile cost half the price of a reinforced concrete one of the same length and section, and when to this is added their relative strengths, the cost/strength ratio is 10 to 12. That is to say, to give the same strength, the cost of reinforced concrete will be at least ten times that of timber! This, of course, is based on ultimate strengths and ignores the " factor of safety " question, but it is reasonable to say that, combining strength with cost, reinforced concrete is several times dearer than timber.

Practical Comparison

There is no better method of checking such a statement than by a comparison of works actually carried out and in use. An excellent example of the modern method of design in reinforced concrete is that of a jetty on the Thames (referred to in the Proceedings of the Institution of Civil Engineers for 1928). But is is noticeable that notwithstanding the fact that this is a particularly economical and efficient design, the cost works out at about £90 per foot lineal of jetty. This is a high figure when compared with the cost of similar works before the introduction of reinforced concrete.

As it happens, a very useful comparison can be made with an exactly similar structure erected at a Northern port in the year 1899, of practically the same width and giving exactly the same depth, viz., 26-ft. at L.W.O.S.T.

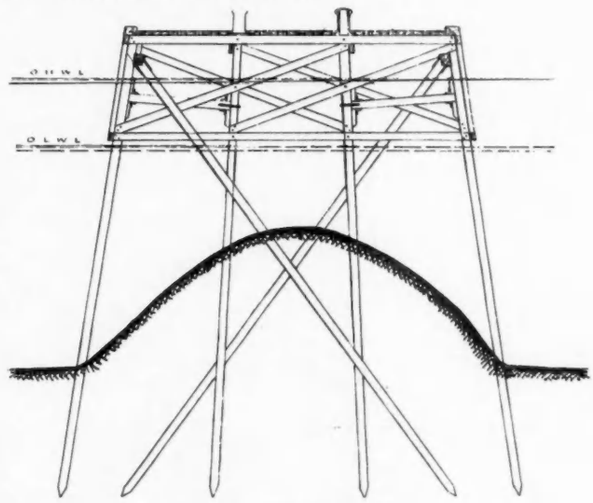


Fig. 1. Cross Section of Jetty.

This is a jetty (fig. 1) built entirely of pitch pine and designed for the accommodation of large ships. In the year 1899 it cost complete £29 per ft. lineal. This figure, reduced to the datum of corresponding prices, would be approximately £45, so that if the jetty on the Thames had been built of timber of exactly similar design, it would have cost to-day half that of the jetty actually carried out there recently in reinforced concrete.

When the facilities given are compared, the discrepancy is even more noticeable. The reinforced concrete jetty gives a berth with 26-ft. at low water on one side only, whereas in the case of the timber jetty, both sides are the same. A considerable addition would have to be made to the £90 per ft. to provide equal depths on both sides.

Further, the reinforced concrete jetty is 50 per cent. longer than the timber one, and the longer a jetty is, the less the price per lineal foot. Also, it is designed for a safe load of 2 cwts. per square foot, whilst the timber jetty has a safe carrying capacity of 5 cwts. per square foot. This is partly balanced by the fact that the former is designed to carry a large crane.

The greatest difference, however, is in the strength. In structures of the jetty type, such as the two cases referred to, as already pointed out, the determining factor is the resistance of the jetty as a whole to bending stresses, however much it is desired to attempt to take up the thrust of a ship by direct compression on piles. Even on such piles, on account of the unavoidably excessive length compared to section and the limiting angle at which they can be driven, bending stresses are decisive, and the relief that such strut piles can give to the principal piles of the structure can only be of secondary importance.

*Owing to the War these figures no longer obtain.

Relative Values of Reinforced Concrete and Timber—continued

It might with truth be pointed out that the figures of 90 to 45, representing the relative costs of the two jetties as actually carried out, do not really show the present-day difference, which would be more in the region of 90 to 35 or 40.

The timber jetty referred to was built in 1899, forty years ago, and would now, judged by modern ideas, be considered unnecessarily extravagant, the amount of timber being excessive. In a length of 411-ft., there are 406 piles each 14-in. by 14-in., giving a sectional area of 552 square feet. In the same length of the reinforced concrete jetty there are only 132 piles, 18-in. by 18-in. = 300 square feet. As a 14-in. square timber pile is stronger than an 18-in. reinforced concrete pile, there is obviously a super-abundance of strength.

Or, approaching from another angle, 406 piles carrying a safe vertical load each of, say, 40 tons = a total load of 16,240 tons, over an area of 411-ft. by 40-ft. = 16,440 square feet = approximately one ton per square foot. But timber decking and joists can only carry safely a load of 5 cwts. per square foot,

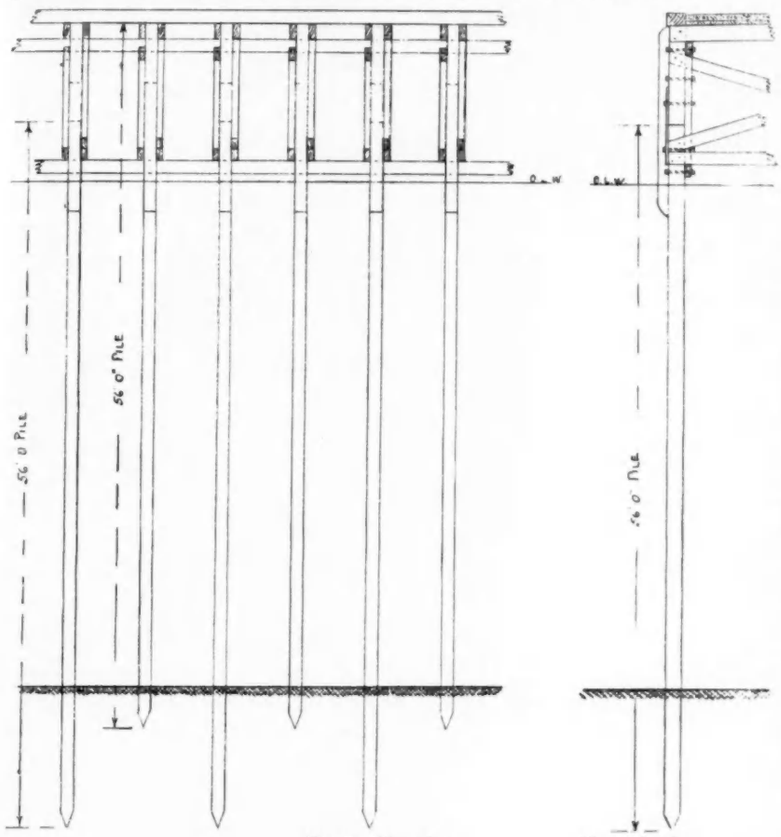


Fig. 2. Elevation. Cross Section.

which is more than ample for a structure of this type, so that there is four times as much timber in piles as is necessary for the vertical load. This bears out the original contention that, in such a case the vertical load does not control.

When the question of resistance of the piles to bending is considered, the discrepancy is even greater—300 square feet sectional area of reinforced concrete piles as compared to 552 square feet of timber, when the same area of the latter has an ultimate strength six times greater than the former. This is qualified slightly by the fact that the 300 square feet of reinforced concrete is distributed in areas of 18-in. by 18-in., whereas the 552 square feet of timber is in areas of 14-in. by 14-in.

As a matter of smaller moment, but which still further increases the discrepancy in the relative price, is the fact that the timber jetty is 40-ft. wide at cope level as against 37-ft. 6-in., the corresponding available width of the reinforced concrete jetty—a difference amounting to nearly 9 per cent.

Relative Life

As to the relative life of the two structures, there does not appear to be any method of comparison. As already pointed out, the timber jetty has never been out of commission since it was built 40 years ago, and since the main part of the structure is as good as ever, it is not possible to put a limit on its useful life. The length of life of reinforced concrete is sometimes given as 25 years, but the grounds for this limit are not very clear.

If the reason for deciding on the use of reinforced concrete instead of timber in the case referred to, is the short life of timber in the waters of the Thames, there will necessarily be a large sum for renewal of the fenders, consisting of three 14-in. by 14-in. Oregon pine piles.

From the foregoing it is clear that a timber structure would not only have been eminently superior to that actually constructed in the Thames, but much cheaper, if attention was confined entirely to the considerations already set out, but no doubt the fact that the owners were cement manufacturers in this particular case was a factor which made the use of reinforced concrete unavoidable.

One noticeable feature in this jetty amounts to a practical admission of the unsuitability of reinforced concrete piles for a structure of this type. This is the fact that it was found necessary, or at least advisable, to place three 14-in. by 14-in. timber piles in front of each bay of reinforced concrete piles in order to protect the latter from being called upon to do the duty which would have been done had timber piles been in their place. Assuming three more on the opposite side, these six timber piles would alone have been sufficient to form the foundation of the jetty, thus removing any necessity for reinforced concrete piles at all.

If concrete piles were decided on because of the short life of timber in these waters, is there any reason to think that these six timber piles are going to have any longer life simply because they are placed alongside concrete piles? Neither efficiency nor economy is suggested by that arrangement.

Length of Piles

In connection with piling for wharves and jetties, however, there is one case in which reinforced concrete has the advantage—and that a very practical one. The increase in the size of ocean-going steamers in modern times necessitates the provision of berths giving a depth of from 30 to 35-ft. at low water, and this presents no difficulty as far as reinforced concrete is concerned, but it is now almost impossible to get suitable timber at a reasonable cost in any quantities over 56-ft. in length. Even if procurable over 60-ft. long, the difficulty of driving timber piles (especially if of Douglas fir) of that length through any hard strata would be, in many cases, practically insuperable. This objection has been overcome in several instances with some success by butt-jointing the piles with steel fishplates, but, no doubt, in course of time a structure of this sort would not have the strength of one with continuous piles from ground level to cope level. An alternative is suggested, viz., to drive every alternative pile to a level slightly above low water, butt jointing the upper portion on top, the other pile being kept to cope level (fig. 2) thus:—By this means the extra depth should be obtained with the same length of piles.

Preservation of Timber

On the assumption that the foregoing arguments are well founded, the conclusion cannot be avoided that no material provides so many advantages for sea construction work from the point of view of efficiency and economy as timber, and it would consequently appear that there is a vast field for further research work in the devising of some means of preserving timber and protecting it from the inroads of marine organisms, thus lengthening its life in sea water to such an extent as to place it on an equal footing with reinforced concrete in this respect. Such a result, it is claimed, would be found highly remunerative, and in this connection it may be pointed out that during the last 60 or 70 years little or no progress has been made in the methods adopted. The one practical method commonly accepted, viz., impregnating the pores of the timber with creosote oil under pressure (which has been in use in one form or another for about 70 years), is of doubtful efficacy, and, in all probability, the results achieved do not by any means justify the expenditure incurred. At one period during the last European war, the cost of creosoting timber was actually higher than the cost of the material itself some years previously; and when, as has been found by experience, pitch pine thoroughly creosoted has only had in certain waters a useful life of 10 to 15 years, it will be seen how necessary it is to discover some other method or treatment by which timber could be rendered immune from the attacks of sea organisms and placed on the same level, so far as resistance to decay is concerned, as stone or concrete.

No doubt one of the reasons why so little advance has been made, and why inventors have neglected this field, is the fact that although from a financial point of view the discovery of some effective method would be almost invaluable and would provide ample reward to the successful discoverer, it would take such a lengthy period—possibly 50 years or more—before its complete success could be clearly demonstrated, that the inventor

Relative Values of Reinforced Concrete and Timber—continued

would in the meantime require to devise some means of increasing his own length of life if he were to reap his due reward.

As some indication of the economy which could be effected, it may be pointed out that a modern Port having the good fortune to be so situated that timber structures are practically everlasting in its waters, could be saved—assuming a length of quayage of 30,000-ft.—somewhere between a million and a million-and-a-half sterling in its capital expenditure. Further, this does not by any means exhaust the whole of the saving, as, in the event of alterations or developments in the form of the provision of deeper berths—the most common change in any progressive port—timber is by far the easiest and cheapest form of construction to which such alterations and developments can be made. Stone and concrete gravity walls have either to be removed and rebuilt at an almost prohibitive cost, or underpinned—a dangerous and costly proposition.

Reinforced concrete in the form of a braced structure on piles would not, however, present the same difficulties referred to in the case of gravity walls, but the problem of providing a deeper berth at an existing quay would be much more difficult and expensive than if the structure were of timber.

Defects in Reinforced Concrete

Incidentally, it may be mentioned that while reinforced concrete is absolutely immune from the attacks of sea worms, it has its own troubles in sea water, and the principal one is fundamental. Unlike other substances, cracks form an essential element in this discrete material, and in all probability it is to this fact that the deterioration of reinforced concrete quays experienced in various parts of the world, and especially those recorded in America, is due.

The fact that the existence of cracks in the concrete partner under normal working conditions is no indication of anything wrong, but, on the contrary, is inherent to the design, indicates the essential difference between this and any other known building material. In other materials the existence of even minute cracks would be viewed with alarm and would demand immediate consideration and attention. But in the case of reinforced concrete such cracks are normal and indeed in tests made in America in 1902 it was the appearance of moisture on the under-surface of a beam which indicated the existence of cracks too minute to be observed by the naked eye.

In the case of a quay, the impact caused by the bumping of a vessel would in all likelihood cause these existing normal cracks to widen and so allow of the penetration of salt water, and, alternatively, air, to the enclosed steel—about the worst possible conditions to which the steel could be subjected. This would cause the imbedded steel to corrode, which, increasing thereby in volume, would burst the adjacent concrete, with, in time, disastrous results.

In cases where deterioration has been observed, especially in American ports, experience shows that this is the most common form that trouble in reinforced concrete marine works takes.

As to relative weakness in bending, experience in recent years would seem to bear out the foregoing. The serious disaster to the reinforced concrete quay at Auckland shows the weakness of this type of structure under bending stresses. It is hardly too much to say that, had this quay been constructed in timber with exactly the same scantlings, distance apart of piles, etc., this accident would never have happened, as it is just under the conditions causing the disaster at Auckland that timber has an ultimate strength of six or seven times greater than the reinforced concrete of which this quay was constructed.

Finally, it is nothing short of a financial tragedy that timber has been ousted from its former position of pre-eminence in the construction of quays and wharves, and, in the writer's opinion, unjustly.

Russian Waterway Enterprise

*The Greater Volga Scheme**

The Greater Volga Scheme, one of the most notable waterway development projects in Europe, is now being put into effect by the Union of Soviet Republics. Intercepting the Volga and its tributaries by means of 15 large dams, the scheme provides for the formation of immense artificial lakes on the great Russian plains. The waters so impounded are destined to rotate the turbines of hydro-electric power stations and irrigate several million acres of land.

The Volga itself will be made navigable along its entire course, not only to shallow-draft river craft, but also to large seagoing vessels coming from the Baltic, Black, Azov and White Seas through a system of canals, already constructed and to be constructed in the next few years.

From its sources in the centre of the East European plain, almost in the very heart of Russia, the Volga winds its way south in fantastic zigzags, collecting in its course some 200 tributary rivers and carrying the combined discharges for thousands of miles to the Caspian Sea.

In ancient times the Volga was the main trade route connecting Russia with Iran and other countries of the Near East. To-day it plays an important part in the economic life of the Soviet Union. Large industrial centres have sprung up in its valley; the banks of the Volga and its tributaries are studded with factories and mills; and the once sleepy Volga towns are hives of activity.

The importance of the Volga was increased with the opening of the Baltic-White Sea Canal which, with the Mariinsk Canal system connects the Volga and the Caspian Sea with the White Sea and the Baltic Sea. The Moscow-Volga Canal has still further enhanced the importance of the Volga, along which 30 million tons of cargo are carried annually.

At present, when the water level falls in the summer months, the upper reaches of the Volga are not accessible to vessels of deep draft. However, dams will make it possible to regulate the water level and make the river navigable throughout the season. As the national economy of the U.S.S.R. develops, the cargo to be carried on the Volga will go on increasing until eventually it is expected to reach 120 million tons a year.

The importance of the Greater Volga Scheme is not limited to navigation alone. The 283,000 cubic feet of water which the great river empties every second into the Caspian Sea have enormous potentialities. The promoters of the scheme estimate that these waters are capable of supplying energy equivalent to the quantity of energy to be obtained from a consumption of 30 million tons of coal a year.

The dams, which will raise the Volga, the Oka and Kama waters 65½ to 98½-ft. will enable it to turn out 60,000 million kilowatt-hours of cheap electric energy a year. High-tension lines will carry this energy not only to the Volga district, but also to Magnitogorsk and other industrial centres of the Urals, and to Moscow. In respect of length, the lines to connect the power stations with the centres of consumption have no parallel anywhere in the world. The power they will supply will bring into life many factories and mills and find extensive application in agriculture.

The first two dams intercepting the Volga on its upper reaches at the towns of Uglich and Rybinsk are nearing completion. Above the Rybinsk dam, a huge artificial lake holding nearly 883,000 million cubic feet of water will be formed. This reservoir, while supplying 28,250 cubic feet of water per second, will insure in the upper reaches a channel deep enough for large vessels. Two hydro-electric power stations built at the Rybinsk and Uglich dams will generate 1,500 million kilowatt-hours of energy a year.

A third dam, to be constructed near Gorky, will direct the Volga waters through 400,000 kw. turbines

Below the junction of the Oka and the Volga, a fourth dam will be constructed at the City of Cheboksary, capital of the Chuvash autonomous republic. Its hydro-electric power station will have a capacity nearly double that of the great power station on the Dniepr.

The navigation channel is deepest at the lowest reaches of the Volga beyond the junction of the river's waters with the Kama. Most of the power will be generated at that point. Two hydro-electric power stations at the Kuibyshev dam and one farther down near the town of Kamyshin will have an aggregate generating capacity of 5,400,000 kw.

A seventh dam and power station with a capacity of 1,800,000 kw. will be built still lower, between Krasnoarmeisk and Cherny Yar.

Several dams to be constructed on the Oka and Kama will make these rivers navigable throughout the entire shipping season, while the power stations to be built at the dams will make available a supply of cheap electricity for industry and agriculture.

Along the banks of the Volga below Kuibyshev stretches an extensive steppe zone. Situated 265 to 330-ft. above the river level, the steppes have a semi-arid climate. Further south, starting from Stalingred, on the left bank of the river is an immense territory of semi-desert. It is scorched by the sun and the hot south-east winds carry with them the hot air of the trans-Caspian deserts and clouds of fine sand.

Nature has been very sparing with moisture in this region, but man has undertaken to correct her lapses. The transformation of nature forms part of the Greater Volga Scheme.

A network of irrigation canals along which the Volga waters will be driven by electric pumps will cut through the arid steppes and semi-desert areas, turning nearly 10 million acres into fertile land.

*A notice based on information supplied by the "Russia To-day" Press Service.

Notes of the Month

New Class of Pilots at Liverpool.

The Mersey Docks and Harbour Board have decided to create a new (fourth) class of pilots, for which senior boathands would be licensed in the present emergency, to act as pilots of vessels of small tonnage.

Grain Shipments on the Great Lakes.

For the year ended August 1st, 1940, shipments of grain on the Great Lakes were the largest for several years past, the gross total being nearly 158,500,000 bushels. The war needs of Great Britain contributed largely to the increased movement.

Germanised Petroleum Basin at Rotterdam.

The new oil basin at Pernis, Rotterdam, which is in course of construction has been taken over by the Germans who announced their intention of enlarging it considerably at a cost of more than £200,000. Quayage of nearly 2 miles is to be provided and warehouses built with extensive railway tracks for goods traffic.

New Danish Icebreaker.

It is announced that the Danish Folketing has sanctioned the provision of a sum of 5,000,000 kr. towards the cost of a new ice-breaker, which is to be more powerful than any existing Danish icebreaker and will also be fitted to carry a number of passengers and some quantity of cargo.

Widening of the River Yarra.

The Melbourne Harbour Trust are reported to have a scheme in hand for cutting away part of the south bank of the River Yarra, which will have the effect of widening the bottom of the navigable channel from 220 to 334-ft. The material removed will be used for reclamation purposes at Fishermen's Bend. The object in view is to make the river a " two-way traffic " stream for shipping.

Traffic on the Welland Canal.

The volume of traffic on the Welland Canal during the months of the current year up to August last is reported to be record-breaking. In May the total freight of 2,051,029 tons was the largest for any month in the history of the waterway, having exceeded the previous highest total, viz., 2,029,660 tons for October, 1938. The combined May-June traffic of 3,942,282 compares with the previous two months record of 3,815,528 tons in September-October, 1938.

Promotion of Thrift Among Dock Labourers.

A scheme has been launched at Liverpool under the joint auspices of the Ministry of Labour, the Port of Liverpool Employers' Association and the Transport and General Workers' Union to encourage saving by dock labourers, of whom there are great numbers employed on Merseyside. The scheme enables the dockers, through the system under which their wages are paid at the clearing houses, to purchase 6d. saving stamps when they draw their earnings.

New Traffic Regulations at Petsamo.

According to reports from Sweden, published in *Lloyd's List*, new regulations regarding traffic at Linhammar, the Government harbour of Petsamo in Northern Finland, which is the only direct outlet for the country to the ocean, have been made by the Finnish Government. The object of the regulations is to prevent congestion and they apply to exports as well as imports. It is set out that only those vessels which are provided in advance with a permit may discharge, load or anchor in the harbour.

Girvan Harbour Dredging.

Application was recently made by the Girvan Town Council, Ayrshire, for Government assistance towards the dredging of Girvan Harbour in order to make it suitable for shipping in the event of larger ports being put out of commission by enemy action. At present it is not practicable for fishing boats to enter or leave the harbour at low tide. The Government, however, were not able to give any helpful assurance to the deputation which waited on the Secretary of State for Scotland.

War Damage on French Inland Waterways.

For the resumption of traffic on the inland waterways of Northern France, reconstruction work has been in active operation. On the lower Seine between Paris and Rouen, 37 bridges were destroyed or damaged, and on the upper Seine, 22 bridges. These have now been restored. Practically all the engineering structures across waterways in the Departments of Nord and Pas de Calais were destroyed, but reconstruction is well in hand. Other reconstructive work is being carried out between Sens and Montereau, on the River Yonne, on the lateral canal of the Loire and the canals of the Briare and Loing and those connecting the Rivers Roanne and Digoin, Rhine and Rhone, Marne and Rhine and the Rhone Canal.

New Floating Dock at Washington.

The United States Navy Department are about to instal a new steel floating dock, 482-ft. long and 71-ft. beam, at Washington, D.C.

New Pier at Staten Island, New York.

The United States Maritime Commission has adopted a scheme for the construction of a 500-ft. pier at South Beach, Staten Island, in the port area of New York, for use as a terminal station for training operations on Hoffman and Swinburne Islands in the outer bay.

Malmö Free Port.

The year 1939 is reported to have been a record year in the history of the Malmö Free Port, Sweden. It was visited by 924 vessels of 590,000 tons net, compared with 870 vessels, of 517,700 tons, in 1938. The total quantity of cargo handled was 210,000 tons, against 174,500 tons in 1938.

Progress at Napier Harbour.

Constructional operations at the new harbour of Napier, New Zealand, have reached a stage at which vessels drawing 26-ft. of water can berth at both sides of No. 3 Pier. The breakwater has been extended by 424-ft., that is, to the full extent proposed.

New Lighthouse on West Atlantic Coast.

A new light, radio beacon and fog signal station is about to be constructed at Cleveland Ledge, marking the approach to the Southern entrance of the Cape Cod Canal, Mass., U.S.A. It will be the first important station to be constructed since the consolidation of the former Lighthouse Service with the Coast Guard and the first major station to be established on the Atlantic Coast for a number of years.

United States Harbour Works Postponed.

The new jetty proposed to be constructed by the United States Corps of Engineers in place of the old north jetty at Grays Harbour, Seattle, Washington, is not to be proceeded with for the present. The Divisional Engineer has also reported against the carrying out of certain projected improvements at Ludington Harbour, Michigan, and at Ashtabula Harbour, Ohio.

Proposed Development of Chicago Waterfront.

The Harbour Committee of the Chicago City Council recently appointed a Sub-committee to visit Great Lake ports with a view to similar developments along the Chicago Waterfront. A plan is under consideration which contemplates the removal of the present lakeside drive further inland, in order that a site may be provided for docks, wharves and terminals. It is expected that the U.S. Federal Government will build a 4-mile breakwater to provide the necessary shelter for port operations.

Port of Beira Works.

It was announced at the recent annual general meeting of the Port of Beira Development, Ltd., that the whole of the new works which were being carried out by Beira Works, Ltd., including the fifth deep-water berth, transit shed accommodation, reclamation of land behind the wharves and re-arrangement of tracks, had been completed. The cutting of a new channel across the Portella Bar, to be known as the Carmona Channel, and the deepening of existing channels is in hand.

Southampton Harbour Finances.

At a recent meeting of the Southampton Harbour Board it was reported that for the first seven months of the year there had been a decrease of £22,306 in income, and of only £6,297 in expenditure. The chairman and clerk had consulted the Dock and Harbour Authorities' Association regarding possible Government grants to harbour authorities in financial difficulty, but had been informed that the Association did not propose to take any action at present, leaving each authority free to act as it thought best under the circumstances.

Grain Transport in Argentina.

Records of the Argentine National Grain Commission show that the transportation of cereals and linseed between Argentine ports by river craft during 1939 amounted to 483,513 metric tons, a relatively small quantity in comparison with the 14 million tons conveyed by rail for shipment abroad. Over two-thirds of this river-borne traffic emanated from the Province of Entre-Rios, mainly through the ports of Gualequaychu Victoria, Ruiz and Concepcion del Uruguay. The province of Buenos Aires contributed 23 per cent. through the ports of General Uriburn and Baradero; the remainder came via the ports of Santa Fe and Reconquista in the province of Santa Fe. Of the foregoing shipments by river craft Buenos Aires received 398,743 tons.

Navigational Fog Signals*

By J. W. TONKIN, M.Inst.C.E.I.

THE principal purpose of this paper is to describe briefly the construction of a powerful Navigational Siren Fog Signal for use on an isolated rock, where 360° of arc had to be covered; a secondary purpose is to draw attention to the need for further research on fog signals in general, and on the siren fog signal in particular.

The literature on the subject of sound is considerable; that on the production of it is apparently meagre, so far as pneumatic fog signals are concerned.

3. The Reed Horn. This is usually operated by hand, using air compressed to about 5 lbs. per square inch pressure. It is much more effective than a bell, or whistle.

4. The Acetylene Gun. An explosive signal usually operated automatically by crude acetylene obtained from a carbide-to-water type of acetylene generator. It is a simple reliable apparatus of considerable value for short ranges, as it can be run unattended.

5. The Explosive Fog Signal. This marks a great advance in

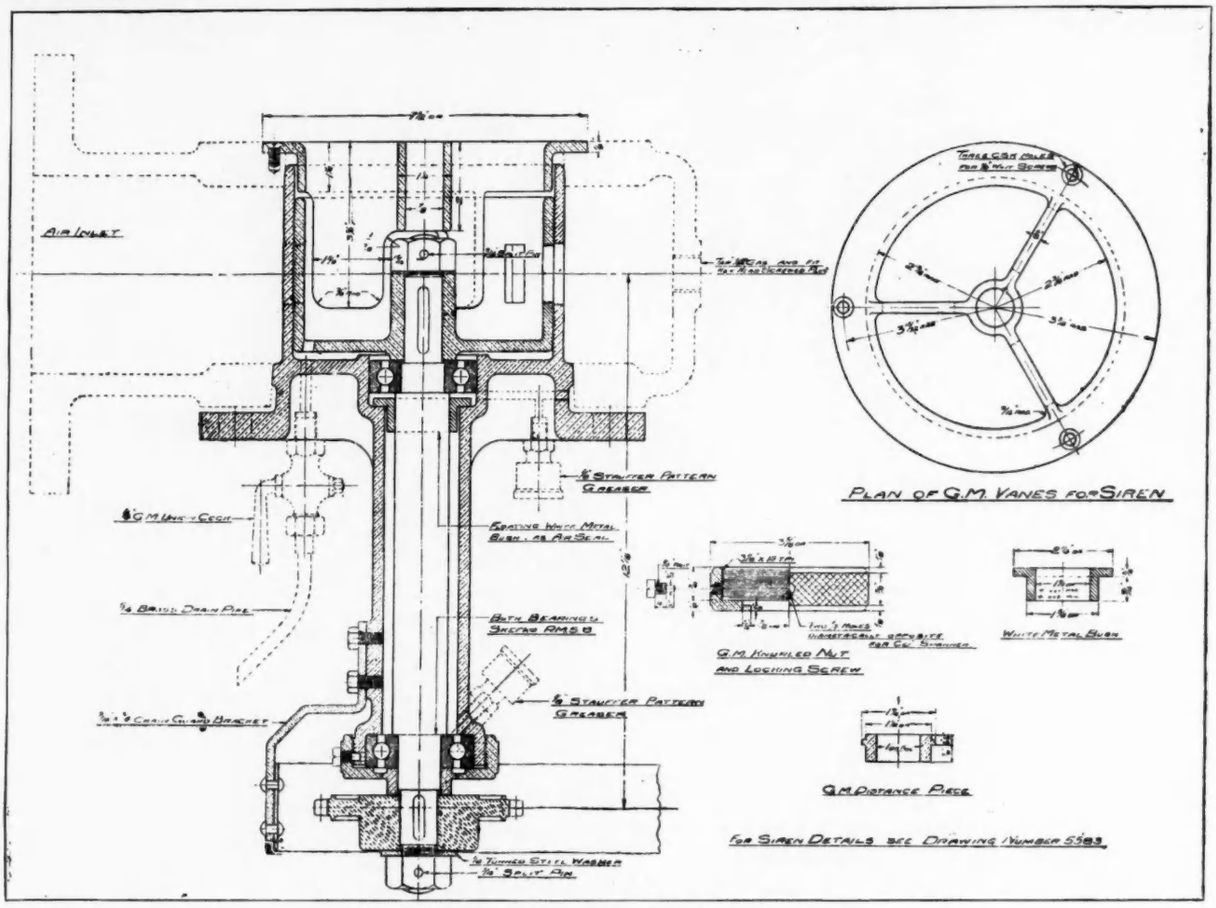

AIR INLET
PLAN OF G.M. VANES FOR SIREN
G.M. KNURLED NUT AND LOCKING SCREW
G.M. DISTANCE PIECE
FOR SIREN DETAILS SEE DRAWING NUMBER 5583

Fig. 1. Bull Rock Lighthouse, 6-in. diam. Siren for Fog Signal.

This is no doubt due to inherent difficulties in ascertaining precisely what takes place in such a short interval of time as is required to produce an audible vibration. But now that the oscillograph has been developed, the actual growth and form of vibration in the throat of a siren can be studied, and with this means available, substantial improvement in the design of the instrument should be possible.

The subject is not without difficulties, however, owing to the many variables which have to be taken into account, the precise effect of each on the others being most complex.

Before going further into this, it might be of interest to mention the various forms of navigational fog signals that are used, for although the subject is one which may not appeal directly to many, the fact that each of us has to contribute towards the provision of them, cannot but arouse at any rate some mild interest. Furthermore, the safer navigation becomes, the lower are the insurance rates against marine risks.

Apart therefore from the humanitarian aspect, efficient fog signals are an economic necessity.

Types of Signals

1. First of all is the Fog Bell. This varies in weight from 3 cwts. when used on a buoy to as many tons on land.

Its effective range is so short that now it is seldom used except on buoys.

2. The Whistle. This is also used on buoys, where it is actuated by air compressed through wave action. In certain types of waves the range exceeds that of the bell, but in short confused seas the latter is to be preferred.

range, as distances of 20 miles or more, are commonly reached.

The report from an explosive fog signal, of which a number are in use on the Irish Coast, is caused by the explosion of a charge of 4 ozs. of cotton powder (gun cutton), which is detonated by a copper-cased detonator filled with about 15 grains of fulminate of mercury.

The detonator is inserted in a paper cartridge of cotton powder, and two short electric leads from it are inserted in clips, which in turn are connected by cables to the firing position. Current is supplied by three dry cells in series (each $2\frac{3}{4}$-in. by $6\frac{5}{8}$-in.) these being sufficient for one year's firing in fog, the intervals between shots being from $2\frac{1}{2}$ to 5 minutes.

At certain important stations, a combination of 4 ozs. of cotton powder, and 2 ozs. of aluminium, in powder form, is used at night. With this explosive a brilliant flash accompanies the report, and in certain types of weather the addition of the flash is of use in locating the signal. It is, moreover, not uncommon for the flash of the signal to be seen without any report being heard, although the intensity of the sound from the compound charge is appreciably greater than that from the lighter plain charge carrying the same weight of cotton powder.

The explosive charge or charges, in the case where two shots are fired in quick succession, are suspended from a davit on which the electric circuit is broken when the davit is in the loading position.

Firing is effected by the closing of a switch by hand at the appropriate time which is given by a bell signal from a clock.

The chief advantages of the explosive signal are low capital cost, simplicity, and satisfactory audible range; the disadvantages are, high cost of maintenance, and difficulty of differentiating between one station and another.

*A Paper read before the Institution of Civil Engineers of Ireland on March 4th, 1940, and reproduced by permission.

Navigational Fog Signals—continued

It is probable that where flash sound charges (which cost just twice as much as plain charges) are used, much smaller charges could be fired together, at half the predominant wave length apart, with much increased acoustic efficiency. But this is a matter which requires investigation, as the cost of the additional detonator required would, with other factors, require to be taken into account.

6. The Siren. A pneumatic instrument of power comparable to that of the gun cotton explosive signal.

A 6-in. diameter (single) cylindrical siren (Fig. 1) is probably at present of rather shorter range than the explosive already described, but for equal cost it can be sounded much more frequently, and may be considered to be of equal value, as in narrow waters it is superior to the explosive for economic reasons.

Further reference to the siren will be made later.

7. The Diaphone. A pneumatic instrument of rather higher efficiency than a siren of equal air consumption.

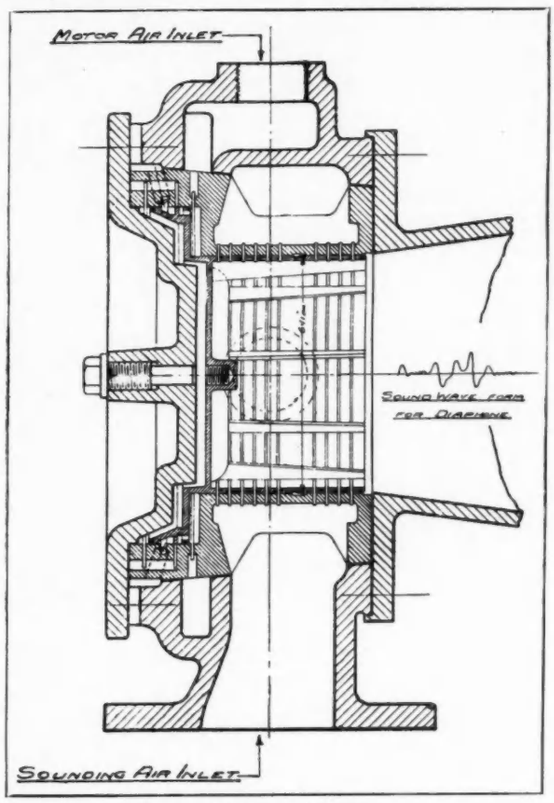


Fig. 2. "G" Type Diaphone.

Sound is produced mainly through the intermittent admission of air under pressure to the small end of a conical resonator. The admission of air is controlled by the movements of a reciprocating piston, along the axis of the resonator, or trumpet. A longitudinal section of a diaphone is shown in Fig. 2 from which it may be seen that the circumferential slits through which the air is admitted into the throat of the instrument open at mid-stroke. The result is that when the diaphone piston is vibrated, it vibrates at half the frequency of the air pressure pulses. A reduction in intensity therefore occurs when the phases of the piston are opposite to the pressure pulses.

This can be avoided by designing a diaphone in which the ports open at each end of the stroke, when there would be no difference in frequency of the pressure pulses, and the movements of the piston.

Vibration is effected by an enlargement of the inner end of the piston which is formed integral with it. On admission of driving air to the front of the radial annular surface joining the two diameters of the piston, this is forced back in the cylinder, when the driving air is admitted to the whole area of the back of the piston, through transfer ports, driving it forward again, where it is stopped by cushioning of trapped inlet air. Meantime the air from the back of the piston is exhausted through a number of round ports to radial passages between the diaphone case, and the back cover, an ingenious and very satisfactory arrangement. The piston, which is of bronze, starts readily, and there is no appreciable wear.

8. The Submarine Bell and the Submarine Oscillator. With these, submarine signals are transmitted from lightships through the water. The bell, which is 14¾-in. diameter and 2¾-in. thick in the heavy sound bow, is operated pneumatically at about 20-ft. below the surface of the water. Air at 20 lbs. pressure is taken to and from the bell by means of a twin flexible hose, power being supplied from the ships air mains, or from an air compressor, driven by an independent 2½ b.h.p. oil engine.

The bell has been largely superseded by the submarine oscillator, which has about two-and-a-half times the effective range. The reason for this is that the oscillator signals are undamped, while those from the bell are at maximum intensity only at the instant that the hammer strikes the bell.

One form of submarine oscillator consists of a short heavy cylindrical casting with a partition across the middle of its length. On each side of this is mounted an electrically excited magnet which attracts an armature secured to the centre of a steel diaphragm of substantial thickness. Each end of the cylinder is closed by a diaphragm, making a watertight joint. The magnets are excited by an alternating current of half the frequency of the sound required.

The frequency of the note sounded in water is normally 1,050 cycles per second, the power input to the motor alternator being about 2 kw. No horn is used.

Owing to the small dimensions of the instrument and the relatively high speed of sound in water, the strength of the signal is nearly uniform in all directions.

The oscillator is suspended by a chain from a davit on the ship's side, and is lowered to a depth of 20-ft. below the sea level.

The submarine signal can usually be heard sufficiently clearly for the needs of small vessels, up to a range of five miles or so, without any special receiving apparatus, the best position for reception being from the fore part of the ship below the water line.

Large ships use special receivers in the form of small water tanks having one open side, which is bolted to the inside of the hull, one on each side of the ship, below the water line, near the bow. In each tank a microphone is wired up to a telephone receiver which can be placed in any convenient place in the ship; ranges of 50 miles or more are common with deep draught vessels, and 15 to 20 miles for shallower ships.

The tanks are arranged so that the screening effect of the fore part of the ship can be used to determine the approximate direction from which the signal is arriving. If the signal is equally loud on both sides of the ship the transmitter is approximately ahead.

For purposes of identification, the signal is sent out in code, and to maintain the correct frequency it is necessary to switch the current over to a dummy (resistance) load in the intervals of silence. This seriously reduces the efficiency of the oscillator, and to avoid much of the loss a combination of a submarine oscillator, and an air oscillator has been used, the exciting current being alternately switched from one to the other.

Although considerable ranges in air have been reached by air oscillators arranged in groups at half wave length apart with the object of flattening the sound field, i.e., contracting it in the vertical plane, and thus intensifying it in the horizontal direction, the frequency of the note produced by the air oscillator remains too high for really satisfactory ranges in air to be reached, even although arrangements are made so that the note sounded is half the pitch of the submarine.

The advantages of the submarine signal are: satisfactory, and constant range; and reasonable low capital, and maintenance cost.

The disadvantages are, that many ships are not fitted with submarine receiving apparatus; and that it cannot be used at many stations owing to practical difficulties of maintaining it where the position is exposed, particularly at rock stations.

The signal is therefore more commonly installed in lightships, where it is often synchronised with a radio beacon signal, the two being picked up by the mariner and used to find both distance and direction, advantage being taken of the difference between the speed of transmission of wireless waves, and that of sound waves through water, for this purpose; direction being obtained by a radio-direction finder, and distance from the lag of the oscillator signal on that of the wireless, the lag being 1¼ seconds per nautical mile.

9. The Radio Beacon. With this wireless fog signal we can don ten league boots, and take another step forward in range, as the radio-beacon can be used for position finding at 200 miles, or more, although really reliable bearings are at present possible for rather less than half this distance. Certain precautions are, however, very necessary, even at this range, bearings obtained at about sunrise, and sunset, and in the proximity of land, being liable to error.

Signals are radiated at present, at scheduled times, twice every half-hour in clear weather, and every six minutes in fog, and as the beacons are clock controlled, and are run unattended, except for some necessary supervision during battery charging, their maintenance cost is low.

General Observations

Having referred briefly to the various types of marine fog signals in more or less common use, some further general references can here be made before the siren is particularly described.

Navigational Fog Signals—continued

The ordinary practice with pneumatic fog signals is to use an air compressor driven by an internal combustion engine, the compressed air being expended intermittently through the fog signal instrument. The operating period of such a signal is usually about 1/12 of the total period, e.g., 5 seconds every minute.

The thermal efficiency resulting from this procedure is extremely low, owing to unavoidable losses in the compressor, including losses in the water jackets; to leakage, and loss of heat from the air during its passage to, and storage in, the air reservoirs.

A possible alternative scheme would be to use say, a 6-cylinder 2-stroke solid injection internal combustion engine, exhausting

If the acoustical frequency was dropped to that of the diaphone (180 cycles) the efficiency of the diaphragm sound sender, or air oscillator as it is sometimes called, would not compare so favourably.

The air oscillator is best adapted for sites where mains current is available, but even there its chief advantage is that it can be run unattended. But it is perhaps doubtful whether Electricity Undertakings would welcome such sudden, and heavy, intermittent demands on their cables, especially in more or less isolated districts.

To cover an arc of 180° at a mean range of 7 miles a consumption suddenly varying from 0 to 15 kw. for 2 or 3 seconds every 20 or 30 seconds would be about the requirements.

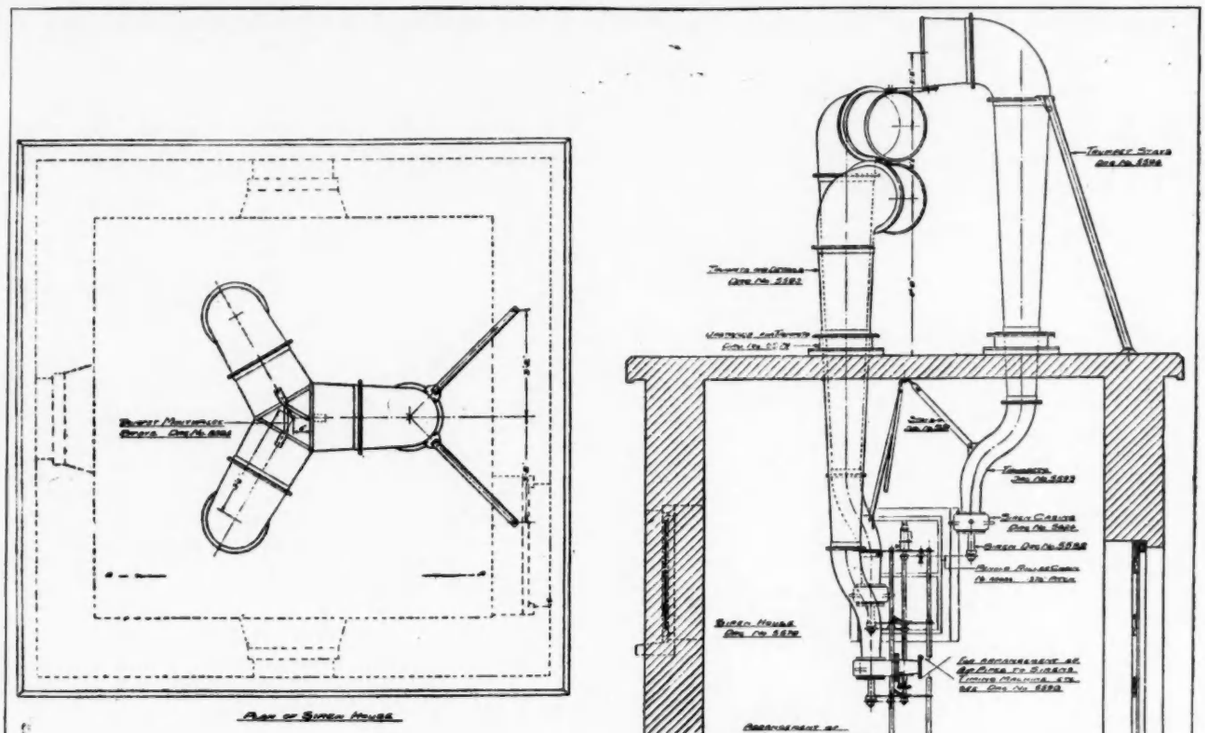


Fig. 3. Bull Rock Lighthouse, General Arrangement of New Siren Fog Signal.

early, and with its exhaust manifold coupled to the small end of a conical resonator, and run at a speed of 1,280 revolutions per minute, a resulting note of 128 vibrations per second being produced, which would be a satisfactory pitch for a fog signal.

Air could be compressed by such an engine during the sounding period, to absorb part of the power developed, this being expended in rotating the engine during the silent interval, during which time the fuel supply could be cut off automatically.

The capital cost of such a plant would be reasonably low, and its efficiency might be sufficiently high to offset the fact that no usable energy would be accumulated during the silent interval which, with this arrangement, could be shortened.

In this connection, the writer has knowledge of several cases in which the exhaust noise of the engine has been the first indication of the proximity of the fog signal. In one striking case the exhaust was from an unsilenced oil engine of only 2 b.h.p. This was a single-cylinder 4-stroke engine, running at 230 revolutions per minute. In another case a 40 b.h.p. single-cylinder, slow speed, gas engine, with the normal cast iron exhaust silencer, and long discharge pipe, was concerned.

It is therefore clear that research in this direction would not be entirely without hope of useful results being achieved.

This is especially the case as Devik and Dahl[1] have shown that the acoustical efficiency of the diaphone is of the order of about 2 per cent. only, in which case the overall efficiency of the orthodox arrangement cannot exceed 1 per cent. A not very satisfactory figure notwithstanding the practical conveniences of existing methods of producing sound by air pressure.

The authors referred to above give the efficiency of the electrically operated diaphragm type of sound sender (acoustical frequency 300 cycles) as 18.8 per cent., the major losses being heat losses in the transmitter 51.8 per cent., and local vibration losses 16.5 per cent.

[1]Journal of the Acoustical Society of America, Vol. 10, No. 1, July, 1938.

The 15 K.W. mentioned represents energy drawn from the mains.

The K.V.A. conditions with alternating current would be approximately:—

1. With a rotary converter and 3-phase current, the power factor would be 0.7
2. Ditto with single-phase current 0.4
3. With static transformer and 3-phase current ... 0.25

So with wider arcs, or longer ranges, or both, the K.V.A. demand would be appreciable and might entail the provision of special long distance lines, which would put the oscillator out of court, especially if a stand-by plant had to be provided.

Siren Signals

In 1937 it became necessary to provide without delay a new siren fog signal at Bull Rock to cover 360° of arc. This was to replace an existing siren, which had to be removed, mainly because of a fall of adjacent rock.

There are, of course, many sirens in use, of various types, and sizes, but none known to the writer sufficiently satisfactory to copy without making some effort towards improvement, so the design of a new instrument was attempted by way of a full scale experiment, a course not to be recommended, as a rule, if it can be avoided.

In deciding on the type, and size of the new siren, the following considerations were kept in view, and it was hoped that a material improvement in the signal strength would result, in addition to a desired acceleration of the character of the old signal.

No experiments or trials of a comprehensive kind have been carried out on pneumatic fog signals since 1901, when extensive tests were made at St. Catherine's Point, Isle of Wight, by the Trinity House Fog Signal Committee.

No striking advances have been made in sirens since that time.

Largely as a result of these experiments, when two Rayleigh trumpets were tested, many tests of special forms of trumpets

Navigational Fog Signals—continued

have been made, with a view to improving the range by making them capable of resonating properly to the note sounded. It was evidently not clearly realised that frequency is the dominating factor in tuning, although this is common knowledge now, and as the frequency sounded from a siren trumpet does not react on the motion of the rotor, the siren is inherently difficult to keep in tune with its resonator, the resonating frequency of which, in turn, varies with changes in temperature.

A siren (Fig. 1) it may be mentioned, is a generator of sound employing one perforated cylinder revolving inside another fixed cylinder, in such a manner that intermittent puffs of air under pressure are led to the small end of a more or less conical resonator, or trumpet. Disc sirens are at least as efficient as cylindrical sirens, but rather more difficult to maintain.

The diaphone, already described, operates by intermittent air pressure too, but in this case the inner cylinder, or piston, which has a closed end, reciprocates along the axis at the small end of the trumpet, and because of this, it is more readily influenced by oscillations set up in the resonator. This influence is however very feeble, and transient, but it can be made to produce a characteristic " grunt " at the finish of a blast from a diaphone, and its associated resonator, and this has considerable value.

Apart from this feature in the diaphone, it is mechanically a far superior instrument to the siren, more particularly for a single instrument of moderate power.

Attempts to increase the power of sirens, or diaphones, by increasing their size, have resulted in their very low efficiencies as machines being made apparently still lower. This is no doubt partly due to the small inertia of air at atmospheric pressure when moved at speeds which are comparatively low in relation to the speed of sound in air, and partly to the fact that as soon as the instruments are made large, in terms of the wave length of the note sounded, they become directional, a property that is generally disadvantageous in fog signals.

These features point to the use of multiple instruments, and here the diaphone is weak, as it is not practicable to keep two, or more independent air-driven instruments in unison, or in phase. This might however be done electrically.

Although heavy beats or a rolling note can be produced from two normal diaphones whose frequencies differ slightly, much better results are to be expected from instruments which can be kept in step. With multiple sirens this means arranging them so that the ports in two, or more, instruments, open precisely together.

It was therefore decided to adopt multiple sirens for the new signal at Bull Rock, as, fortunately, there are no great practical difficulties in keeping multiple sirens in unison or in phase, nor is the cost prohibitive.

Multiple instruments have one obvious advantage, in so far as the failure of one unit does not put the signal out of operation, or seriously impair its efficiency.

In order to obtain sufficient power to cover 360° of arc, it was decided to provide three sirens with 6-in. diameter revolving drums ganged together, with three identical resonators. If however three bent head trumpets, as are usual, are disposed round a common centre pointing radially outwards, and the centres of the mouths are in the same horizontal plane, they will offer appreciable mutual obstruction, and what is worse, the separate sounds will in general reach distant points out of phase, because their points of origin vary in distance from the observer.

This can be avoided by turning the bent heads of the resonators radially inwards, so that their virtual mouths (about half radius outside of the actual mouths) meet in a common vertical line, thus locating the origin of the sound, so far as a distant observer is concerned, at one point.

This is a matter of the greatest possible importance. It was pointed out by Lord Rayleigh long ago in a lecture to the Royal Institute (17th January, 1902), and it is just as important now, as it was then.

The arrangement of the sirens as described is shown in Fig. 3.

The well-known Rayleigh form of trumpet is one with an elliptical mouth, the long axis being vertical in order to produce acoustic interference in the vertical direction, and to cause the sound to spread horizontally.

The trumpets shown in the figures just mentioned are an adaptation of this principle, the mouths (in the aggregate) being about 6-ft. long, and the width 2-ft.; while the mouth is virtually twisted horizontally through an angle of 240° to ensure even distribution. This proved on test to have been accomplished quite satisfactorily.

Now, if two sources of sound, small in comparison to the length of wave emitted, are placed half a wave length apart, the radiation of sound in the line joining the two sources is very little; that is to say, if two points are disposed vertically above each other, the sound field strength in the vertical direction is of limited angle, while the sound is concentrated in the horizontal plane, which is what is required, as a rule, for a fog signal. Two resonators at any rate can be thus disposed, i.e., with the centres of their mouths half a wave length apart. This has been done before, but not for an all-round signal.

Three or more resonators could be similarly disposed, but with reasonably long wave lengths as required for navigation in fog (the unit distance apart being half a wave length), constructional difficulties, and increased cost arise.

In the case of Bull Rock sirens, it was decided to fix the outer two horns with the centres of their mouths half a wave length apart vertically, and the third one midway between these two. This middle horn increases the vertical angle of spread of the sound, but not unduly, and as the mean level of the sirens is 297-ft. above sea level, an appreciable vertical angle is advisable in case vessels get too close to the rock in fog before hearing the signal, as however powerful this might be, audibility at a distance in all conditions of the atmosphere is not to be relied on.

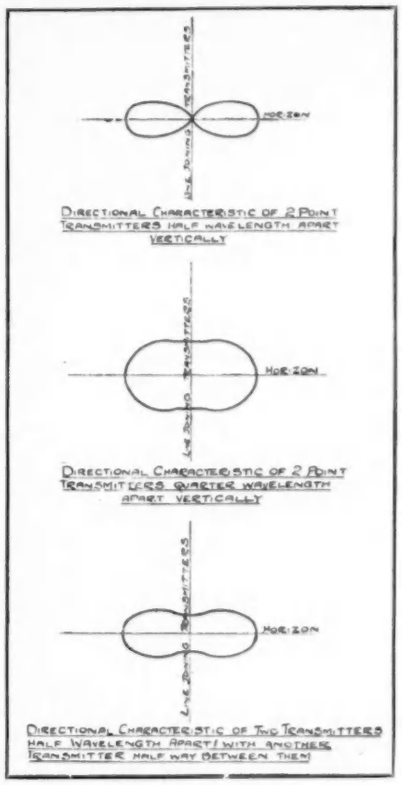

HORIZON
DIRECTIONAL CHARACTERISTIC OF 2 POINT TRANSMITTERS HALF WAVELENGTH APART VERTICALLY
HORIZON
DIRECTIONAL CHARACTERISTIC OF 2 POINT TRANSMITTERS QUARTER WAVELENGTH APART VERTICALLY
HORIZON
DIRECTIONAL CHARACTERISTIC OF TWO TRANSMITTERS HALF WAVELENGTH APART WITH ANOTHER TRANSMITTER HALF WAY BETWEEN THEM

Fig. 4.

A diagram of the probable vertical directional properties of the scheme is shown on Fig. 4. This is based on information taken from a pamphlet by Hecht, and from a paper by Ulrich John, both of the firm of Electro-Acoustic, Kiel.

It may be mentioned that in Lord Rayleigh's monumental work, "Theory of Sound," the author shows that the obstruction offered to sound by a sphere whose circumference is half a wave length is such that the difference in intensity between the posterior and anterior poles amounts to about 1 per cent. only.

The interference caused by the stems of the two upper horns at Bull Rock must therefore be inconsiderable, it is in fact too small to detect by ordinary means.

Lord Rayleigh shows that the bigger the mouth of a trumpet, the more the sound from it is concentrated on the axis, and that when the mouth does not exceed half a wave length the intensity is nearly uniform in all directions. A small mouth (in the limit, a point source) producing a spherical field.

This fact, one easily proved by experiment, has often been overlooked, and has led to sharp differences of opinion on the merits of particular types of sirens, the difference caused by different trumpets being overlooked.

The relation between the diameter of the mouth of a trumpet, and the wave length sounded must always be taken into account, especially when designing an instrument to cover satisfactorily a specified arc.

In a letter (No. 48 CN 4287/1909) circulated by the British Admiralty in 1909, to all H.M. ships, it is stated that " the only condition affecting the carrying power of a siren is the direction of the wind; the direction towards which the siren is pointed within the above limit (which was 135°) being immaterial."

This may have been true for a particular type of siren, under fixed conditions as to steam supply, but it is not at all true in

Navigational Fog Signals—continued

the general sense. It all depends on the diameter of the mouth of the trumpet, and the wave length sounded.

In the discussion (p. 61 *et seq* of the report) at the Lighthouse Conference 1929 on the comparative merits of vertical conical trumpets, and similar trumpets with flared ends, and mushroom tops, strong preferences were expressed in favour of one, or the other; but no mention was made of the ratio $\frac{\text{Diameter of mouth}}{\text{Wave length}}$ in the case of the plain trumpet, nor of the ratio $\frac{\text{Height of mouth}}{\text{Wave length}}$ in the case of the mushroom trumpet.

If the fraction mentioned is small in each case, the result will be, substantially, a spherical field for both forms. It is perhaps excusable to suppose that the flared end and mushroom top over a vertical trumpet would disperse the sound more or less in a horizontal plane, but actually, the top of a normal mushroom trumpet is seldom more than a wave length in diameter and, because of this, it must necessarily be the very poor reflector that it is. Moreover, to produce a satisfactory acoustic interference in the vertical plane (in order to increase horizontal range) the mouth would require to be well over half a wave length in height, and then the top would be of little use for excluding rain, or spray. If the top is not considered as a reflector, but is taken as being part of the boundary of the trumpet, or resonator, the sudden change in cross sectional area, taken in steps along the axis, increases the acoustic impedence of the trumpet, and, as a resonator, its efficiency becomes poor.

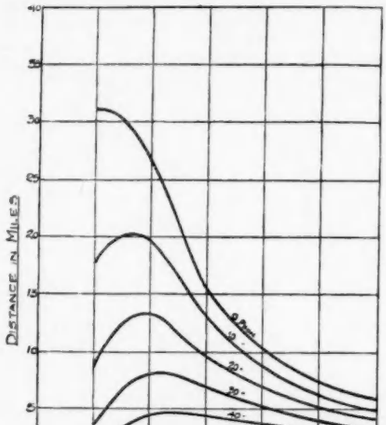


Fig. 5.

Distances of equal sound intensity corresponding to the pitch of tone for an acoustic output in air of 10 KW in calm weather at medium absorption and uniform atmospheric temperature.

Flaring the mouth modifies the tone from a trumpet, while the angle of a conical trumpet also modifies the tone, wide angles causing the note to sound flat, and dull, and narrow ones reedy in comparison.

Siren horns are not usually made to a logarithmic curve, as are the horns of modern loud speakers, but are constructed with a straight taper, as the acoustic impedence of such low notes as are used for fog signals (100 to 200 cycles) is small.

The length can be calculated to a sufficiently high degree of precision for ordinary conical resonators. It is given by this expression:—

$$\lambda = 2\left(L + \frac{d}{4}\right)$$

where λ = the wave length in air.
L = the length of the cone complete to its apex.
d = the diameter of the mouth.

From which it may be noticed that a conical pipe acts as an "open" pipe although it is in fact closed at one end.

Cutting off the apex of a cone and attaching a siren (cylinder) modifies the pitch in inverse proportion to the alteration in the cubic capacity.

The wave length mentioned above is, of course, the speed of sound in air (taken for the present purpose as 1,110-ft. per sec.) divided by the frequency of the note.

The pitch adopted at Bull Rock is 128 vibrations per second. This is an octave below middle C of the pianoforte.

The standard pitch of the diaphone as recommended by the manufacturers is 180 vibrations, and it is quite possible that this is as good, or perhaps better than 128 vibrations in some types of fog.

The difference is not material however. It is rather a question of 128, or 256 vibrations. In a fog, without much wind, and with the ship stopped, or nearly stopped, the 128 vibrations would have the advantage.

Sounds of *low intensity* are relatively better at *low frequencies*. At very high intensities (a road drill) there is a slight tendency in the other direction.

Fig. 5[2] shows the variation in range of sounds of definite degrees of loudness with *variation of frequency*. In this the 20 phon line corresponds[3] to about the average noise level of a suburban garden.

The peak of this line is about 180 vibrations.

To hear a signal of about 20 phons the ship would have to be stopped, and it rather looks from this that 40 phons would be necessary to overcome the average background of ship noises; 40 phons is about the noise level of a saloon car[3] at 30 miles an hour. The peak of this line it may be noted is at about 256 vibrations.

The diagram (Fig. 5) is stated to correspond with calm weather of medium absorption, and uniform atmospheric temperature. In fog, the weather would usually be calm, and of uniform temperature, but the absorption would be greater than medium.

It is therefore clear that ships ought to go slow in fog if for no other reason than to reduce background noises, and the more these are lessened, the greater the advantage of low notes

The question of using an audiometer for actually measuring the loudness of fog signals has been considered, but although such instruments can be obtained, they appear to be still either too delicate for use on board a ship, or to measure something different to what is heard.

This is because of the fact that there is really no simple relation of wide application between physical intensity, and loudness. In other words, if the intensity levels of two pure sounds of different frequencies which appear to be equally loud are increased, or decreased, by the same amount, the sounds will not in general remain equally loud.

The acid test for a fog signal will, for the present, have to be its ranging qualities in fog, as observed by the Mariner.

The first thing to determine in designing a fog signal is the pitch of the note to be sounded.

At Bull Rock the pitch decided on was, as stated, 128 vibrations per second, and while there is no special virtue about this particular note for fog signalling purposes, it is reasonably certain that the most suitable pitch lies between 120 and 240 vibrations per second, the mean being 180 vibrations per second, as adopted by the makers of the diaphone.

Having decided on the pitch of the note, the dimensions of the trumpet, or resonator, are easily determined.

If the sound is required to cover a large arc, the horizontal width of the mouth should not exceed one quarter of the wave length, but the height of the mouth can be increased to $1\frac{1}{4}$ wave lengths, especially if the sound generating source is of considerable power, and consequently large.

Some care in the interpretation of Fig. 5 is necessary, as, at first sight, it appears to indicate that weak sounds carry further than stronger ones. It is, of course, not intended to show this, but simply to show the effect of change of frequency, on sounds of various degrees of loudness, e.g., if a sound has a strength of 20 phons at 5 miles with a frequency of 500, it will have the same strength at about 13 miles, if the frequency is dropped to 200. This is shown by the diagram.

For very long ranges to be reached, the diagram indicates that comparatively low frequencies are best. This is because at feeble intensities the ear exercises a pronounced selective preference for notes of medium frequency, and it is only at high intensities that equal increments of energy produce even approximately equal increments of loudness.

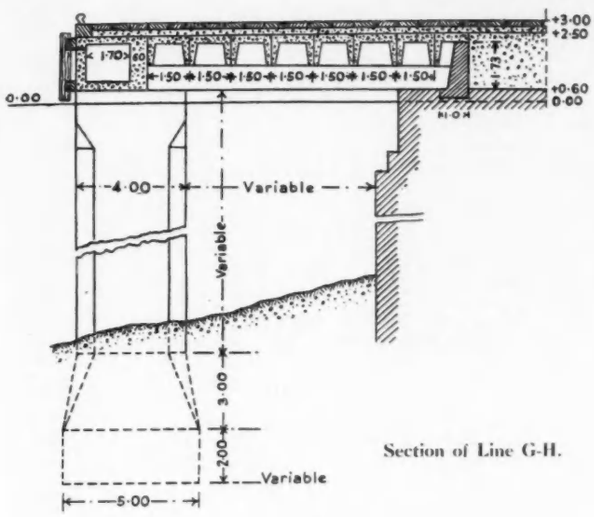
The sensitivity of the human ear varies greatly with the pitch, having a sharp maximum at about 1,500 cycles, the sensitivity falling steeply at higher pitches.

From these facts one can decide with certainty that the best pitch for a sound that will carry well lies between 100 cycles and 1,500 cycles; a very wide gap it is true, but in average fog probably the region of 180 cycles is the most effective, 50 cycles either way having no material effect on the range, although it is certainly inadvisable to have high and low notes sounded alternately.

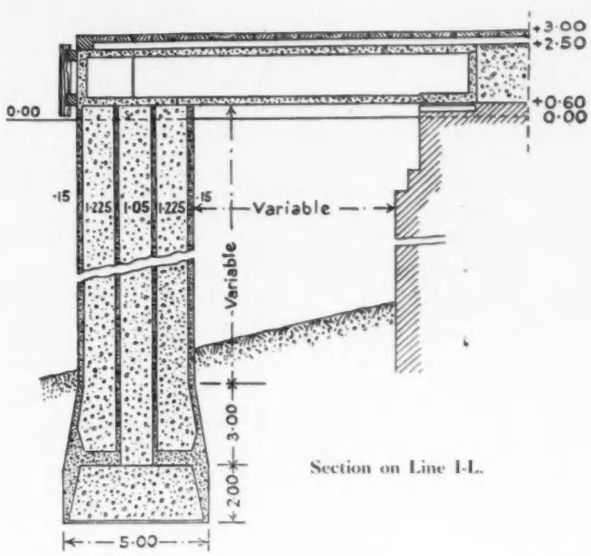
In connection with the question of pitch it is of interest to note that of the two factors in human speech the energy is at a peak at about 150 cycles, while the intelligibility is at a maximum at about 1,000 cycles.

(To be continued).

[2] Ulrich John, Berlin Lighthouse Conference, 1937.
[3] "Engineering," 13th May, 1932.



Section of Line G-H.



Section on Line I-L.

Port of Messina

Reconstruction of Quay following Earthquake

In consequence of earthquake shock some years back, the quay frontage at the Port of Messina, Sicily, suffered serious damage and disturbance, with subsidence of the entire structure. The following is an account, from an article in the *Annali dei Lavori Pubblici* of the reconstruction of a portion of the quay lying between the Customs House and the projecting market, extending over a distance of 366 lin. yds. The work was carried out between 1932 and 1938.

Abandoning the idea of adopting for the new quay a wall of massive artificial blocks on account of the difficulty which would have been encountered in founding conveniently and economically on a particularly sloping bottom, where the most modest and indispensable installation of landing places would have involved considerable and indefinite demands, it was necessary to evolve a type which would allow of the execution of the work without the necessity for precautionary excavation in front of the old quay and the provision of safeguards. Accordingly an openwork type was adopted, with superstructure of reinforced concrete carried on pillars.

The pillars, or columns, of reinforced concrete, sunk by excavation under compressed air down to a level varying between 45 and 55-ft., as far, that is to say, as was necessary to reach a stratum of a sandy nature, constitute the detached supports of the superstructure which is composed of a frontal tubular girder with transverse beams, and secondary beams of inverted U section resting on the latter.

The work was executed in two stages and with two different arrangements.

In the first of these, for a length of 416-ft. along the Custom House frontage, the columns were arranged with the larger parallel to the coping of the new quay, as a result of which the transverse beams are tubular.

In the second arrangement, for the remaining length of 682-ft., the columns have been placed more rationally with the greater width at right angles to the frontage.

The foregoing systems in addition to being executed at less cost than a structure of artificial blocks, offer the following advantages:—

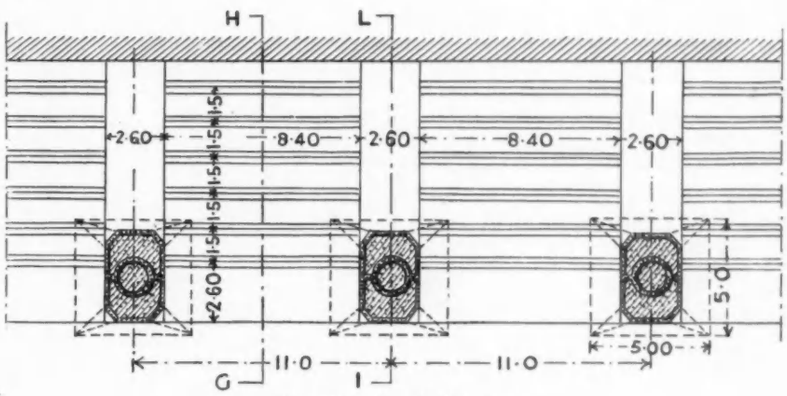
(1) More rapid execution and a reduced area required for working yard;

(2) The possibility of proceeding to the excavation in front of the new quay on completion of the work, and not necessarily beforehand, so avoiding disturbance of stability in the old wall;

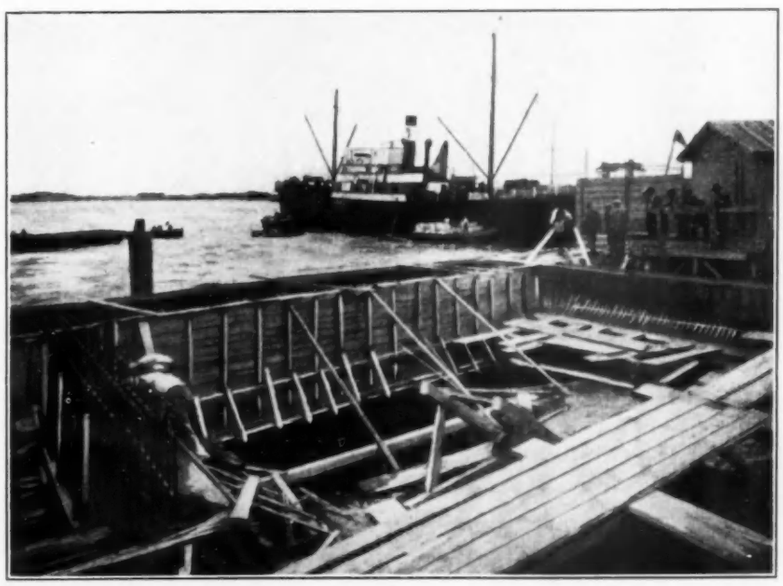
(3) The possibility of expansion of wave swell under the new structure, so removing the need for a continuous parapet wall to counteract the effect of wave impact.

The new quay has its coping at the level of 10-ft. above water surface level and on account of the special nature of its structure and of the new profile, the wall is now forward of the old work to the extent of 16 to 33-ft.

Details of construction and a general view of the new quay are shown in the sections and photographs which accompany this article.



Plan of Portion of the Quay.



Mould for the Superstructure of the Quay Wall.

Tides in the Swan River Estuary, Western Australia

By ALLAN BENNETT, B.E., B.C.E., Associate Member of the Institution of Engineers, Australia.*

Summary.—This paper is complementary to an earlier paper by the author in which investigations undertaken to determine the reasons for the unsatisfactory prediction of tides at Fremantle, Western Australia, were described. One of the reasons was discovered and a method was devised for the approximate prediction of tides at that port. In this paper, the manner in which the tide waves travel up the Swan River, and how they are altered in transit, is discussed.

On completing a study of the tides at Fremantle, the results of which have already been communicated to The Institution,† the author became interested in the action of the tides in the estuary of the Swan River.

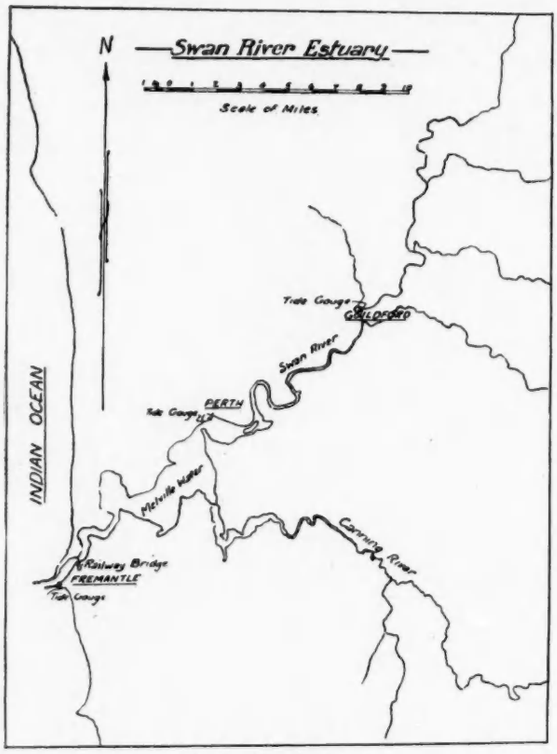


Fig. 1. Locality Plan.

The locality plan shows that the Swan River and the Canning River both discharge into a large sheet of water known as Melville Water, which in turn discharges through a comparatively narrow channel (Black Wall Reach) and the Fremantle Harbour into the Indian Ocean.

In the year 1928 automatic tide gauges were in operation at Arthurs Head, Fremantle, at Mill Street, Perth, and near the railway bridge at Guildford. The present investigation was made possible by the courtesy of the Engineer for Harbours and Rivers in Western Australia (Mr. J. Stevenson Young) in making these tide records available to the author.

A study of the tides in the Swan River involves a study of their propagation from Fremantle up the river. The causes and effects of the tides at Fremantle had already been determined and if therefore the problem of how these tide waves travelled up the river and how they were altered in transit was settled, it would then be possible to predict future levels and their times in the river.

Tidal Ranges

The Tidal Ranges for the year 1928 for Fremantle, Perth and Guildford were tabulated, averaged and plotted as shown in Fig. 2.

The average tidal range for Fremantle was 1.364-ft., for Perth 0.804-ft., and Guildford 0.708-ft., so that the range at Perth and Guildford averaged, respectively, 59% and 51.8% that at Fremantle.

The proportion, however, is not uniform for all ranges, it being too low for low tides and too high for high tides. A more exact determination may be made by means of the following empirical formula:

$$P_R = CF_RN = 0.65\,F_R^{0.76}$$

where P_R = range of tide at Perth in feet
and F_R = range of tide at Fremantle in feet

Similarly the range of the tide at Guildford may be obtained by the following formula:

$$G_R = 0.537\,F_R^{0.94}$$

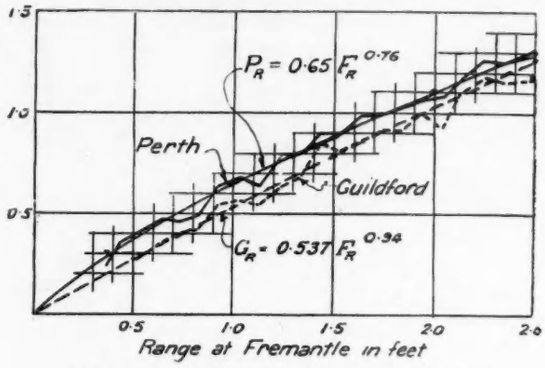


Fig. 2. Tidal Ranges for Fremantle, Perth and Guildford for the Year 1928.

It will be noticed that this last formula gives practically a straight line when plotted.

It is interesting to note that the expansion of the tide into Melville Water considerably reduced the range, whilst the run up the comparatively uniform stretch from Perth to Guildford had very little effect.

Times of Tide at Perth and Guildford

To determine the velocity of the tide wave up the river, the time intervals from Fremantle were plotted as against the tide gauge reading at Fremantle (Fig. 3). Several interesting features were disclosed. Firstly, for a given gauge reading at Fremantle the velocity up the river was constant; this result is remarkable when the great variations in the widths of the estuary

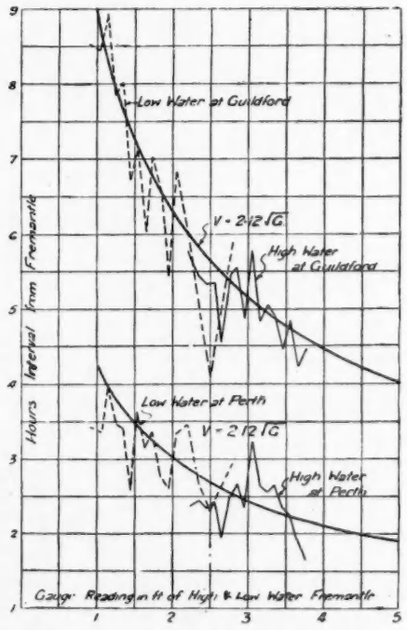

Low Water at Guildford
V = 2.12 √G
High Water at Guildford
Low Water at Perth
V = 2.12 √G
High Water at Perth
Hours Interval from Fremantle
Gauge Readings in ft of High & Low Water Fremantle

Fig. 3. Tidal Velocity in the Swan River.

and river are considered. It was found that the velocity of the tide wave was given by the formula:

$$V = 2.12\sqrt{G_F}$$

where G_F = gauge reading at Fremantle.

Secondly, it was discovered that this formula applied not only to high water but also to low water. This meant that a high water reached Perth or Guildford much quicker than a low water, with the result that at these places the tide rose more

*This paper No. 702, originated in the Perth Division of The Institution. The author is Superintendent of Works, Fremantle Harbour Trust.

†"The Tides at Fremantle, Western Australia," published in the May, 1940, issue of this Journal.

Tides in the Swan River Estuary, Western Australia—continued

quickly and fell more slowly than at Fremantle. Figure 4 shows the comparison between a 2-ft. tide at Fremantle and the corresponding tides at Perth and Guildford. The fact that a tide rises more quickly and falls more slowly, the greater the distance from the outlet of a river, is common to all river tides, and in extreme cases where conditions are such that the time of rise approaches zero the phenomenon known as a "bore" is experienced.

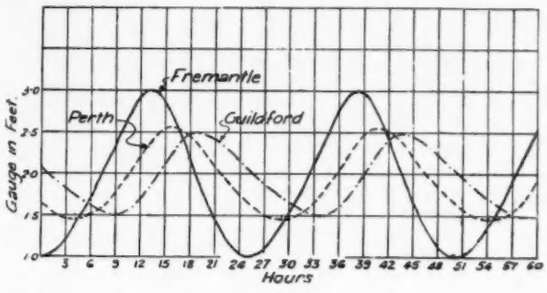


Fig. 4. Comparison Between Tides at Fremantle and at Perth and Guildford.

Tidal Current

The study of currents induced by tidal action is very interesting. Contrary to the usual belief that "slack water" at the outlet of a river occurs at high or low water, the exact opposite is the case. The maximum tidal current occurs at either high or low water, and slack water occurs when the level of the water coincides with the mean water level. That this is reasonable is evident when it is considered that the maximum hydraulic gradient exists at high or low water. From Fig. 4 it will be seen that slack water occurs at Fremantle approximately 7hr. 30min. after low water.

Observations taken at the railway bridge at the eastern end of the harbour on 30th August, 1930, showed that slack water occurred 5hr. 20min. after high water on that day, and that the current then reversed itself from 2.4 knots upstream to 2.4 knots downstream in a period of less than 15 min.

It can be shown that the velocity of the tide stream varies as $\sqrt{R}$ where R = range of tide. A formula for the velocity at the railway bridge at the east end of the harbour is

$$V_B = 1.84 \sqrt{R_F} \text{ knots}$$

It will be noticed that this velocity is less than that for the tidal wave and care should be taken not to confuse the two.

Mean Water Level

It was found that the mean water level at Perth fluctuated in harmony with the mean sea level at Fremantle, that is to say, it varied according to the barometric pressure, and complied with the annual tide wave in exactly the same manner as at Fremantle.

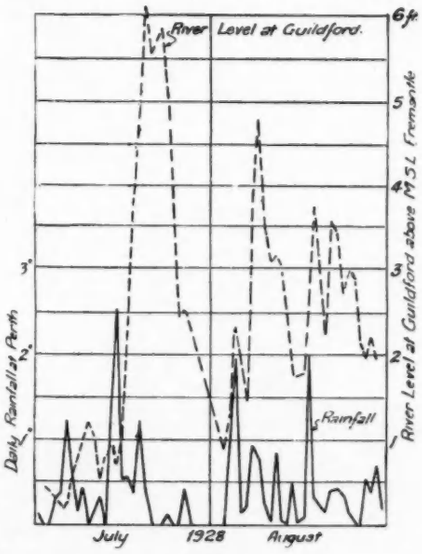


Fig. 5.

In addition, however, the level at Perth was affected by flood waters. In the winter time, after heavy rains, considerable rises are experienced in the river at Guildford. A typical flood record is shown in Appendix I, showing the variation from July 12th to July 26th, 1928.

In Fig. 5 the river level at Guildford above mean sea level at Fremantle is plotted for the months of July and August, 1928, and on the same diagram is shown the daily rainfall at Perth for the same period. Generally speaking, it takes a period of four days for the run-off from a heavy rain to be concentrated at Guildford. The heaviest fall of 254 points in one day, raised the water level to 6.16-ft. some four days later; a smaller fall of 198 points raised the water level to 4.75-ft. above Fremantle, again four days later. There also appears to be a cumulative effect over the two months in that the river level generally at Guildford

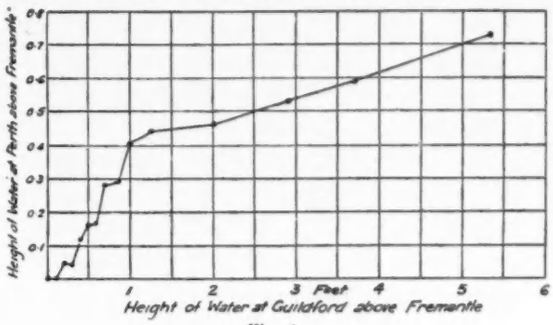


Fig. 6.

was raised to 2-ft. above Fremantle over the two months, and the effects of the individual days rains were superimposed on this.

A corresponding, but diminished, variation was observed with the water level at Perth. Figure 6 shows the water level at Guildford plotted against the water level at Perth, averaged over the year 1928. It will be noticed that a rise of 5-ft. 4-in. at Guildford corresponded with a rise of 9-in. in the water level at Perth.

Maximum Water Levels.

From the data in the foregoing, together with that already set out in the author's paper on "The Tides at Fremantle," it is possible to obtain some idea of the maximum height to which the water level at Perth is likely to reach, and also the most likely time for this to occur.

The maximum height of mean water level occurs when the sun has reached its maximum declination north, i.e., about 21st June. Its value would then be $2.27 + 0.37 = 2.64$. To this must be added the rise in water level due to flood waters, say a maximum of 0.74-ft. making a total of 3.38-ft. This last rise is most likely to occur in July or August. To this must be added the semi-range at spring tides to obtain the height at high water.

The range of the tide at Fremantle has been shown to depend on the declination of the moon. The maximum declination of the moon, however, varies considerably, ranging from approxim-

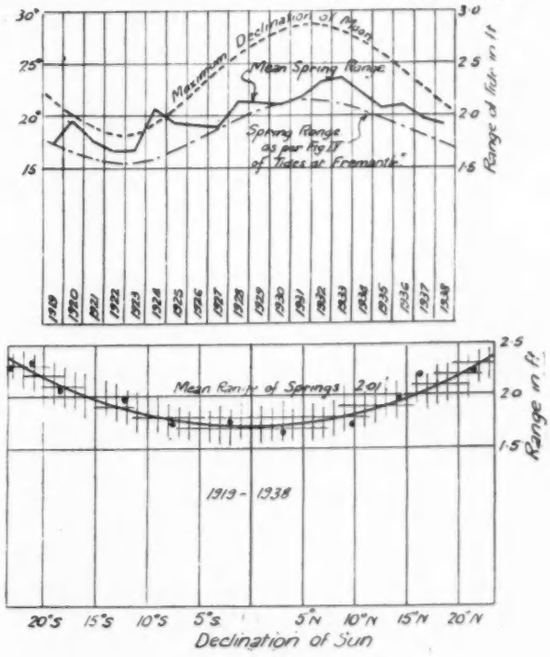
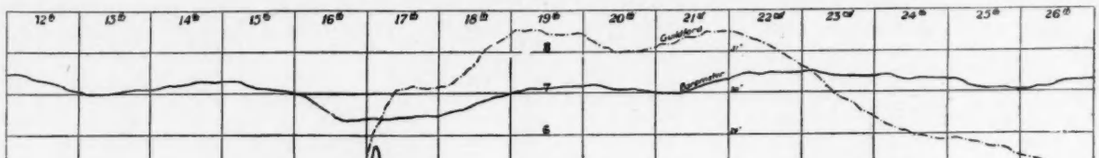

Declination of the Moon
Maximum
Mean Spring Range
Spring Range as per Fig 17 of "Tides at Fremantle"
Range of Tide in Ft
Mean Range of Springs 2.01'
1919 - 1938
Range in Ft
Declination of Sun

Fig. 7.

ately 18° to 28°. The cycle of this variation has a period of 18 years and 7 months. This cycle is clearly shown in Fig. 7 (a). It will be noticed that the cycle reached its maximum in 1931-32 and should again reach its maximum about 1950. The spring semi-range will then be 1.14-ft. at Fremantle corresponding with a semi-range of 0.72-ft. at Perth, so that high water will be 3.38-ft. + 0.72-ft. = 4.10-ft.

Tides in the Swan River Estuary, Western Australia—continued

APPENDIX I.



TYPICAL FLOOD RECORD. July, 1928.

To the above high water level must be added the possible effect of barometric pressure. The lowest barometer reading of 29.132-in. occurred on 26th February, 1915. Assuming, however, a drop to 29-in. this would correspond to a rise in water level of 1.4-ft. making a total high water level of 5.50-ft.

Mean Water Level	2.27-ft.
Semi range of Solar Annual Tide	0.37-ft.
Barometer drop to 29-in.	1.40-ft.
Flood waters	0.74-ft.
Semi-range of lunar declinational tide ...	0.72-ft.
Total H.W.L.	5.50-ft.

It may, therefore, be said that under present conditions the maximum level to which the river at Perth is likely to reach is 5-ft. 4-in., and the most likely time for this to occur is in July of 1950.

Previous records show that the maximum registration at Perth occurred as follows:—

July 1928	5.15-ft.
July 1930	5.30-ft.

Effect of Swan River Improvements

The effect of the present improvements to Swan River, consisting of deepening and reclamation, is not likely to be very great. The restriction of the water area will increase the range of tide at Perth and by restricting the storage for storm water it will also increase the effects of flood water. To compensate for this, however, deepening will reduce the hydraulic friction and will enable flood waters to escape more easily (it will also permit the tidal wave from Fremantle to reach Perth more quickly).

If, however, the extreme development is reached of making a channel from Perth to Fremantle, say, 1,400-ft. wide and 36-ft. deep, the effects will be more marked.

The velocity of the tide wave will be that given by the formula for a uniform channel—

$$V = 3.36\sqrt{h}$$

where V = rate in knots
and h = depth in feet

and the full effects of the tide wave will reach Perth from Fremantle in less than half-an-hour. The maximum tidal range at Perth will also be increased by an amount not exceding 0.96-ft.

Flood waters from the Upper Swan will have free egress and this would reduce the water level by an amount not exceeding 0.74-ft. The net result will be an increase in probable maximum level of 0.22-ft., i.e., from 5.35-ft. to 5.57-ft.

A secondary effect, however, that might eventuate is the generation of a river seiche. This consists of a secondary wave superimposed on the normal tide waves. Its period would approximate that given by the formula

$$T = \frac{4L}{\sqrt{gh}} \text{ or roughly 1.8 hr.}$$

As this period does not coincide with any of the known tide generating forces the amplitude of the seiche would be small, and its occurrence (if any) would be irregular.

From the foregoing it would appear that practically any improvement or alterations to the Swan River can be effected without materially altering the existing water levels at Perth.

Port of London Authority

Excerpts from the Thirty-first Annual Report for Year ended 31st March, 1940

National Emergency—The War

With the deterioration of the international situation in the early part of the year under review, the Authority pressed forward the completion in detail of the various emergency schemes designed to afford protection to personnel and to ensure continuance of the functioning of the Port in the event of a national emergency.

These precautionary measures included the setting up of emergency organisations at the Head Office and the Docks; the provision of air raid shelter accommodation at the docks; the adaptation and equipment of various premises for use as Air Raid Depots, First Aid Posts, etc., and the training of staff for the special services required; the provision at the docks of accommodation for Fire Brigade units, and the necessary protective works, particularly of vital points, throughout the undertaking.

Premises were taken outside the port area for use as Emergency Headquarters for certain of the staff and were subsequently occupied.

About 4,300 volunteers from the staff of the Authority and their contractors were trained for the Air Raid Precautions Services and similar training was provided for about 2,000 of the staff of shipowners and tenants at the docks. Anti-gas instruction was given to about 3,200 persons comprising the Authority's "key" staff (including Police), River Emergency Service Volunteers and Lightermen.

In August, 1939, when the international situation became critical, the Port of London Emergency Committee, which at that time existed as an advisory body, was reconstituted by the Minister of Transport, all the present members of the Authority being appointed members of the committee, with the Chairman and Vice-Chairman of the Authority as Chairman and Vice-Chairman respectively of the Committee. The Committee appointed Mr. J. D. Ritchie, M.C., General Manager of the Authority, to be their Chief Executive Officer. On the declaration of war on the 3rd September, 1939, the Minister made an Order, viz., "The Control of Traffic at Ports Order, 1939," conferring powers on Port Emergency Committees to issue directions for regulating, facilitating and expediting traffic at ports.

The emergency organisation prepared before the war provided for the setting up of two Executive Bodies, viz., the Port Labour Executive and the Lighterage Emergency Executive. On the outbreak of war these Executives at once commenced to function, the former under the joint Chairmanship of Mr. R. T. Garrett and Mr. T. W. Condon, O.B.E., and the latter under the direction of a Chief Executive Officer, Mr. H. L. Collard, and the Authority have recorded their appreciation of the invaluable services rendered by these bodies in the interests of the port.

Immediately preceding the declaration of war the various emergency schemes of the Authority were put into operation. The transition was effected smoothly and the Authority rapidly adapted their organisation to meet war-time conditions.

The River Emergency Service, intended primarily to deal with casualties on the river and organised by the Authority on behalf of the Ministry of Health, was mobilised on the 1st-2nd September on the instructions of the Ministry. The Authority are reimbursed the expenses of operating the service but have agreed to bear a moiety of certain initial expenses of a capital nature and to provide the necessary administration.

On the 20th October, 1939, Sir Ernest Gowers, K.C.B., K.B.E., and Admiral Sir Edward R. G. R. Evans, K.C.B., D.S.O., Commissioners for the London Civil Defence Region, with Mr. Harold Scott, Chief Administrative Officer, visited the docks and expressed themselves as greatly impressed with the

Port of London Authority—continued

thoroughness and efficiency of the Authority's Air Raid Precaution arrangements and organisation.

Special services have been rendered to the Government by the Authority, including salvage and dredging operations outside the port limits and assistance in the evacuation and dispersal of certain foodstuffs from the port.

Several of the Authority's craft were requisitioned by the Government for war purposes.

Dr. M. T. Morgan, M.C., Medical Officer of Health for the Port of London, has been appointed to undertake the duties of Port Anti-Gas Officer.

With the view of augmenting their Police Force, a War Reserve Police was formed of volunteers from the Authority's Upper and Lower Division Staffs. The members of this Reserve rendered loyal service from the outbreak of war until the recruitment of temporary constables for the period of the war enabled them to resume their normal departmental duties.

The total number of employees serving with H.M. Forces at 31st March, 1940, was 419 and in addition several of the Authority's officers and staff have been engaged on special duties for certain Government departments.

The Authority decided that regularly employed staff (including permanent labourers) engaged on war service with H.M. Forces should be made an allowance sufficient to bring the amount of pay and allowances received from the Government up to the employee's rate of pay in the Authority's service at the outbreak of war.

The following Emergency Orders relating to Explosives and Petroleum were made by the Minister of Transport under the Defence Regulations, 1939:—

(a) The Government Explosives in Harbours Order, dated 4th September, 1939.
(b) The Petroleum Spirit in Harbours Order, dated 4th September, 1939.

These Orders dealt with the loading, unloading, storage and conveyance within all harbours in the United Kingdom of ammunition or explosives held for the service of a Government Department. and of petroleum spirit.

A subsequent Order, viz., "The Petroleum Spirit (River Thames) Order, 1939," contained special provisions regarding the conveyance of petroleum spirit on the Thames.

Finance

The capital expenditure for the year ended 31st March, 1940, amounted to £585,661, the principal items being:—

	£
Construction of new quay and sheds	360,129
Dredging, etc., Mudfield Site, Royal Victoria Dock ...	31,970
Quay cranes and crane rails, King George V Dock	27,698
Air Raid Precaution Works	124,965

The following is a summary of the year's working:—

Total Revenue	5,743,797
Total Expenditure	4,185,660
Balance of Revenue	1,558,137
Less—Interest on Port Stock and Temporary Loans, Sinking Fund Charges, etc., less interest, etc., receivable	1,909,915
Dr.	351,778
Balance brought forward from 31st March, 1939	370,637
Leaving to be carried forward	£18,859

The expenditure during the year on account of the General Fund for the Maintenance and Renewal of Premises and Plant and for Dredging was £73,261, and after transferring £100,000 from Net Revenue Account for the current year in respect of normal Renewals and Replacements, etc., and providing £225,000 to meet expenditure on Maintenance, Renewals and Dredging postponed in consequence of the war, the balance standing to the credit of the Fund at 31st March, 1940, was £527,585. The General Reserve Fund amounts to £1,050,000 and is fully invested in Trustee Securities. The amount standing to the Credit of the Insurance Fund at 31st March, 1940, was £617,798.

Works and Improvements

The Authority have been requested to withhold details of many works and improvements carried out during the year.

Surrey Commercial Docks.

The electrification of a berth and the installation of a 750 K.W. converter are in hand.

The construction of a new four-storey warehouse has been completed.

River.

The two new Diesel-engined launches under construction for the Harbour Service have been completed and placed in commission.

A small dredger and three hopper barges have been purchased for work on the Surrey Canal and the upper reaches of the River.

General.

During the year new electric quay cranes previously ordered have been delivered and taken into use.

Under an arrangement with the London County Council, the Authority agreed to contribute to the cost and reconstruction of ten bridges involved in the Council's scheme of road improvement in the vicinity of the docks. Five of the bridges have been reconstructed and one is nearing completion.

The more important works in hand during the year for the maintenance of the undertaking included the modernisation of lifts and hoists at Cutler Street and Commercial Road Warehouses and Surrey Commercial Docks, the provision of a 3-ton overhead electric travelling crane at each of four gantry sheds and the re-roofing of certain sheds, also the overhaul of the outer lock gates at the Upper Entrance, Royal Albert Dock, and at the Lower Entrance, Tilbury Docks.

Dredging operations in the river have been restricted owing to war conditions but during the year 675,436 cubic yards of material have been removed in order to maintain and deepen the channels.

The quantity of mud removed from the docks during the year was 1,088,674 cubic yards.

General

Under the terms of an agreement between the National Council of Port Labour Employers and the Transport and General Workers' Union and its associated Unions, certain increases in rates of pay of dock labourers and other grades of workers whose rates of pay are regulated by those paid to dock labourers were brought into operation on 13th November, 1939.

In order to meet the increase in operative costs and the large expenditure incurred upon war emergency measures throughout the undertaking the Authority applied to the Ministry of Transport for authorisation to increase certain of their rates and charges and as a result the Minister made an Order, viz., "The Port of London (Increase of Charges) Order, 1939," under the provisions of the Defence Regulations.

The following increases were accordingly brought into effect on the 4th December, 1939:—

River duties of tonnage on vessels; Surrey Canal Tolls and Charges; Port Rates on Goods; and Navigation Tolls for vessels carrying merchandise westward of London Bridge, increased by 7½ per cent.

Rates and Charges (including rent):—On Import Goods; on Goods for Shipment; on Shipping using the Authority's Docks; for discharging vessels and other services shewn in the Shipping Schedule (other than the supply of tugs, towage of craft and barges, and the supply of water, electricity and gas); for use of Dry Docks and Appliances; and for use of Oil Separator Barges:—

Where shewn in the appropriate Schedules as net figures the rates and charges, including rent, increased by 7½ per cent., and where shewn as subject to percentage increases the following revised percentage increases applied, viz.:—

2½ per cent.	increased to 10 per cent.
5 per cent.	increased to 12½ per cent.
10 per cent.	increased to 17½ per cent.
12½ per cent.	increased to 20 per cent.
15 per cent.	increased to 22½ per cent.

The decline in the Authority's revenues due to the war rendered it necessary for the Authority, in anticipation of their financial requirements for the ensuing year, to seek power further to increase their rates and charges as from the 1st April, 1940, and an Order, viz., "The Port of London (Increase of Charges) Order, 1940," was made accordingly by the Minister on the 21st March.

The Authority have been requested to withhold the usual details of work done by the Wreck Raising Service.

The Ministry of Transport made an Order entitled "The Port of London Authority's (Elections and Appointments) Order, 1939," extending for one year the term of office of the existing Chairman, Vice-Chairman and other members of the Authority and making provision for the election of members in 1941 to be held on the Register of Voters formed during the twelve months ended 31st October, 1939.

Presentation to Dock Manager.

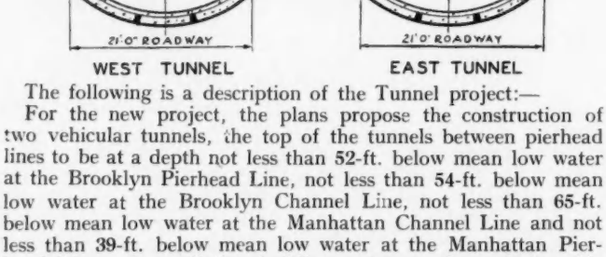
On the occasion of his retirement from the position of Dock Manager at the Great Western Railway Company's Millbay Docks at Plymouth, Mr. E. W. Gould has been the recipient of a silver Chippendale salver from his colleagues in the Docks Department of the Company. The presentation was made at Cardiff by Mr. W. J. Thomas, Chief Docks Manager, with eulogistic references to Mr. Gould's high personal qualities.

Proposed New York–Brooklyn Tunnels

The Port of New York Authority operates two tunnels under the Hudson River: The Holland Tunnel and the Lincoln Tunnel, both of recent construction. They have proved of signal advantage in linking up Manhattan Island with New Jersey, and have proved so successful from both constructional and traffic points of view that a third (twin) tunnel is about to be bored under the East River to connect Manhattan with Brooklyn.

The project is being promoted by the New York City Tunnel Authority who have recently applied for a permit from the United States Secretary of State for War to carry out the work. The route of the tunnel starts at a point on the Manhattan Pierhead Line at the Southern top of the Island and passes in a very slightly South-easterly direction under East River and Buttermilk Channel to a point on the Brooklyn Pierhead Line at Red Hook.

The idea of a bridge to span the waterway was rejected by the U.S. Corps of Engineers and the State Office at Washington as forming a serious impediment to navigation.



The following is a description of the Tunnel project:—

For the new project, the plans propose the construction of two vehicular tunnels, the top of the tunnels between pierhead lines to be at a depth not less than 52-ft. below mean low water at the Brooklyn Pierhead Line, not less than 54-ft. below mean low water at the Brooklyn Channel Line, not less than 65-ft. below mean low water at the Manhattan Channel Line and not less than 39-ft. below mean low water at the Manhattan Pierhead Line. A ventilation building not more than 125-ft. wide and 150-ft. long will be constructed to the east of a point on Governors Island known as Ordnance Wharf 136, the west end of the building being not more than 20-ft. east of the east end of Ordnance Wharf 136. The aforesaid ventilation building will have a protecting bulkhead extending 35-ft. beyond the sides of the ventilation building.

During the construction of a portion of the tunnels it will be necessary to place a temporary clay blanket in Buttermilk Channel. The top of the temporary clay blanket will be not less than 4.5-ft. below mean low water at the Brooklyn Bulkhead Line, thence extending northwardly on a descending grade to an elevation not less than 15-ft. below mean low water at the Brooklyn Pierhead Line, thence on a descending grade to an elevation not less than 20-ft. below mean low water at a line 135-ft. channelward of the Brooklyn Pierhead Line, thence on a level grade to an elevation not less than 20-ft. below mean low water at a line 575-ft. channelward of the Brooklyn Pierhead Line, thence sloping downward at a rate of approximately 1 vertical to 4 horizontal to the intersection of the original river bottom at a line approximately 650-ft. channelward of the Brooklyn Pierhead Line.

Publication Received

We have received a copy of a revised report on The Ports of San Francisco, Oakland, Alameda, Richmond and Upper San Francisco Bay, California, compiled by the Board of Engineers for Rivers and Harbours, War Department, and the United States Maritime Commission, and published as Port Series No. 12. Reports in this series cover the principal ports of the United States and are prepared to meet the needs of the Government and to supply data for use of importers, exporters, manufacturers, railroads, steamship lines, and others interested in the development of harbours and the establishment of port facilities.

In the present report the information compiled by the Board of Engineers is presented in Part 1 and the subjects covered by the Maritime Commission comprise Part 2 of the volume. Part 1 gives information with regard to port and harbour conditions, fuel and supplies, the services available to commerce and shipping, including piers, wharves, hoisting facilities, grain elevators and warehouses, storage warehouses, bulk freight storage, dry docks and marine railways, marine repair plants, floating equipment, wrecking and salvage equipment, radio service, and airports and air lines. Railroad services and rates at the ports are discussed and tables are presented showing in detail the commerce at the ports for the ten-year period 1928-37, inclusive, and a statement of the commerce for the calendar year 1938.

The information compiled by the Maritime Commission and presented in Part 2 of the report covers port customs and regulations, port labour and methods, employed in handling cargo, port and terminal services and charges, steamship services, rates, and rate conferences, and territory tributary. In the chapter on territory tributary tables are presented showing the foreign, noncontiguous, and inter-coastal waterborne commerce of San Francisco Bay ports for the calendar year 1937, by commodities and ports of origin and destination.

Copies may be obtained, price $1.75, from the Superintendent of Documents, Government Printing Office, Washington, D.C.

Retirement of Bombay Port Engineer

The retirement of Mr. G. E. Bennett, after 14 years service, from the office of chief engineer to the Port of Bombay Trust is made the occasion for a biographical sketch in " The Port of Bombay " quarterly magazine. Mr. Bennett is an M.Sc., of Manchester University and a member of the Institutions of Civil and of Mechanical Engineers. He went out to India in 1910, as an assistant bridge engineer with the Great Indian Peninsular Railway. Six years later he was appointed Port Engineer at Chittagong, a post which he held until he joined the Calcutta Port Trust in 1919 as an executive engineer. There he was attached for a time to the special staff engaged on the construction of the King George's Dock, and he was Deputy Chief Engineer in charge of the work. In 1926, he entered the service of the Port of Bombay Trust as Deputy Chief Engineer, being appointed to the Chief Engineership in 1930. During the later years of his service, Mr. Bennett was called upon to act as chairman of the Port Trust on several occasions. At a recent meeting, the Board placed on record their appreciation of the valuable services he had rendered in the discharge of his responsible duties.

Obituary

The death at the age of 65 has recently been announced of Mr. W. H. Blaker, M.Inst.C.E., formerly chief engineer to the Isle of Man Harbour Commissioners. Mr. Blaker's early technical training was acquired under Mr. P. Nevill, chief assistant to the late Mr. James Walker, M.Inst.C.E., who at the time held the position of Chief Engineer to the Commissioners. During 1897, Mr. Blaker was employed as resident engineer on extensions to the Queen's Pier at Ramsey, which were completed in 1900, by which time he had been made chief assistant engineer. He then went to South Africa where for four years he was on the staff of Sir John Jackson, Ltd., contractors for the Simon's Bay Naval Dockyard. In 1904, he became divisional engineer of the Congella Port Development Scheme at Durban, but relinquished this appointment during the following year, in order to return to the Isle of Man as Chief Engineer to the Harbour Commissioners, and here he remained until his retirement in 1936. During his term of office, he carried out extensive repairs to the old Battery Pier and the widening of the Victoria Pier, both at Douglas and was responsible for other works at Port Erin and Ramsey. He prepared and executed a scheme of harbour improvements at Douglas, including the new King Edward VIII. Pier inside the harbour which was opened by Sir John (now Lord) Simon in 1936.